GOVERNOR'S DROUGHT TASK FORCE

IRRIGATED AGRICULTURE WORK GROUP

DRAFT REPORT

September 28, 2004

IRRIGATED AGRICULTURE DROUGHT PLAN
DRAFT-9-28-04

I. Introduction And Background

Economic Importance of Arizona's Irrigated Agriculture

Agriculture has a long and storied history in Arizona. Historians report that the Hohokam civilization disappeared from the Salt River Valley in the mid-1450's after having lived and farmed in the Valley for more than a millennium. Domestic livestock was introduced into Arizona by Spanish settlers in the early 1500's. Modern day farming activity in the Salt River Valley dates back to 1868 when Jack Swilling first diverted water from the Salt River to irrigate 1,000 acres of farmland. (Gammage, *Phoenix in Perspective, 1999).* The farming and ranching industries have been a primary factor in Arizona's economic wellbeing for over 500 years, producing food and fiber for the citizens of Arizona, the United States, and for export to overseas markets.

Agriculture's presence in Arizona is well documented. When Arizona became the 48th state to enter the United States on February 14, 1912 the State seal reflected images of the agricultural sector, as well the original "4 C's for which the state was known. Cotton, Citrus, Cattle and Copper speak volumes about the importance of agriculture to this great state.

Objective of this Plan

The objective of this plan, consistent with the Executive Order authorizing it, is to

> Assess the vulnerabilities, risks and impacts of drought on Arizona's irrigated agriculture sector and develop response, mitigation and adaptation strategies to sustain the long-term economic viability of the State's irrigated agriculture in the event of protracted drought.

For purposes of this report the impact of drought on commercial cattle feeding and dairy production operations are included (see Chapter II Annex, "Dairies and Feed Yards"). The rational for this is that the bulk of these operations reside within the identified groundwater active management areas and are subject to Arizona's Groundwater Code.

Additionally, these confined operations are impacted by drought more similarly to irrigated agriculture than range livestock.

Drought and Irrigated Agriculture

Drought impacts agricultural water supplies and water demand. The extent of the impact can vary significantly from one irrigation district, or farmer, to another based on many factors. Agricultural water users are impacted by meteorological, hydrological and socioeconomic drought. As precipitation declines (meteorological drought), systems reliant primarily on surface water supplies will be impacted more immediately than groundwater dependent systems that draw on water supplies stored over thousands of years. Systems with deep wells in productive alluvial aquifers will be less impacted than systems with wells in fractured rock or near streams that experience widely fluctuating groundwater levels in response to climate conditions. This impact on supply from long periods of precipitation shortfall is referred to as hydrologic drought, which typically lags behind meteorological drought. Additionally, as groundwater levels or surface water supplies diminish, water quality can become a concern. In droughts, water demand typically increases as farmers apply more water to meet crop demand in response to increased temperatures which generally accompany drought. In cases where drought severely impacts agricultural water supplies, economic impacts may result at the irrigation district, at the farm, and in the community. These types of impacts are collectively called "socioeconomic drought".

Less water for delivery by irrigation districts impacts their revenue stream while increasing costs of system maintenance and the possibility of increased power costs as increased reliance on groundwater supplies is needed to replace surface water supplies where applicable. Farmers may face changes in cropping patterns and farm management methods that generally have negative impacts on farm income. Ultimately, severe drought conditions can lead to fallowing of irrigated land negatively impacting the financial wellbeing of the farming operation. In acute situations there may be short term community impacts, less crop inputs purchased, and decreased use of farm labor. In chronic drought situations local communities with dependence upon production agriculture for their economic viability will be impacted.

Recent and past droughts have impacted agriculture water users a number of specific ways. Information on these impacts has been reported from several sources. These include the 2002 University of Arizona – CLIMAS Study *Vulnerability to Climate Variability in the Farming Sector-A Case Study of Ground water Dependent Agriculture in Southeastern Arizona* and numerous reports provided by irrigation water managers and producers at various forums addressing the impact of drought on Arizona's agriculture during 2004 (see, for example, Chapter III Annex, "Impact of the Drought on the San Carlos Irrigation District").

The Irrigated Agriculture Work Group consisting of representatives from the agriculture water community from across the state, developed a drought survey targeted at the irrigated agriculture community. The survey was developed in mid-2003 and distributed to 42 irrigation district managers statewide. By the end of 2003, twenty-three completed surveys had been received from irrigation districts located in Yuma, Yavapai, Maricopa, Pinal, Graham, and Pima counties, covering nearly every region of the state and accounting for an estimated 2,352,000 acre feet of water delivered to approximately 686,600 acres of farmland.

The drought survey questions covered the general areas of:

- Irrigation District Water Supply Sources
- Drought Vulnerability
- Drought Impacts
- Drought Response, Mitigation and Adaptation

The survey results are discussed in detail in the following chapters and represent the most important source of data for the reports findings and recommendations. The survey instrument and results can be found in Appendices to each of the Report's remaining chapters.

The survey represents a snapshot in time, late 2003. The drought has worsened since then, and several respondents have stated that responses might be different if the survey had been distributed during late 2004.

Eastern and South Eastern Arizona

For purposes of this report, areas in Eastern and South Eastern Arizona will be discussed under separate subheadings in this and subsequent chapters. Geographically, this discussion covers the Upper Gila – Safford Valley area, as well as the Sulphur Springs Valley, that is, agricultural areas lying roughly between Wilcox and Douglas. These areas are discussed separately because there is only one large irrigation district in the entire area, thus additional data sources are used. In the case of the Upper Gila –Safford Valley, our survey of district managers includes a single response – the 23rd – received in early 2004, from The Gila Valley Irrigation District. Unlike Central and Western Arizona, discussion of drought and irrigated agriculture in Eastern and South Eastern Arizona is based on that one survey, as well as interviews with agricultural interests. The GVID does not deliver water, but represents ten different canal companies within the District. The canal companies deliver water to farmers who also irrigate with privately owned wells. Some canal companies also own wells. The GVID encompasses about 35,500 acres, most of which are cropped annually.

In the case of the Sulphur Springs Valley, where irrigated agriculture completely relies on ground water delivered from privately owned wells, we rely on data collected by a team of researchers from the Bureau of Applied Research in Anthropology, at the University of

Arizona under the supervision of Drs. Timothy J. Finan and Marcela Vásquez-León[1]. Their work is summarized in this report, and an electronic version can be found at http://www.ispe.arizona.edu/climas/pubs.html.

Where Does Arizona's Irrigated Agriculture Get Its Water Supplies?

Irrigated agriculture in Arizona uses three primary sources of water. These are surface water from the Colorado River mainstem and CAP canal; surface water from other principal Arizona streams, of which the Gila, Salt-Verde, Agua Fria, and Santa Cruz River systems are the more important; and ground water. State law also recognizes two other water sources, so called 'in-lieu' water and effluent. Physical in-lieu water derives from CAP and effluent. Effluent was a supply source in only two responding districts. Locally occurring precipitation is of relatively minor importance over most of Arizona's more important irrigation districts, but for districts relying on surface water, precipitation on often distant watersheds is the original water source.

Use of surface water depends on flow volumes – which vary annually – and is governed by priority of claim or permit, as detailed on page 15 of the Operational Drought Plan. For those irrigating with surface water, vulnerability to drought in Arizona irrigated agriculture is importantly influenced by priority of use. In other words, the ability to irrigate with surface water would depend in large part on the volume of available water and on the priority rank of the user. Available volumes and priority rank are legal, institutional, physical, and hydrologic in nature.

Use of ground water depends on location, specifically whether or not the use (point of diversion) is located within one of the State's five active management areas (AMA's). For those irrigating with ground water at this writing, vulnerability to drought is related more to physical and hydrologic factors than to legal and institutional ones. There is discussion of groundwater management in Arizona on pages 13 – 15 of the Operational Drought Plan.

So, the vulnerability of irrigated agriculture relying on irrigation district deliveries is mostly influenced by how many water sources are available to the district; water volumes available to the district by source; related surface water priorities; and related physical and hydrological limits on ground water withdrawals.

Concerning individual growers, or groups of growers, who irrigate and are located inside of irrigation districts, some use only district supplies, some use both district supplies and their own individual wells, and some use only their own individual wells. When district

---

[1] . Marcela Vásquez-León, Colin Thor West, Barbara Wolf, Jane Moody, and Timothy J. Finan. *Vulnerability to Climate Variability in the Farming Sector – A Case Study of Groundwater-Dependent Agriculture in Southeastern Arizona.* The Climate Assessment Project for the Southwest (CLIMAS). Institute for the Study of Planet Earth, The University of Arizona, Tucson. CLIMAS Report Series CL 1-02, December, 2002.

supplies are curtailed, for example by drought, individual growers may replace district supplies by increasing their private ground water withdrawals, to make a full complement of water.

An important amount of irrigated Arizona agriculture relies on ground water withdrawn by individual growers, who may or may not also have access to irrigation district supplies. At this writing, in general, for those individual growers irrigating with ground water withdrawn from their own wells, vulnerability to drought is primarily related to the same physical and hydrological limits faced by wells owned, leased, or operated by irrigation districts. Ground water for irrigated agricultural use by individual pumpers is an important water source in Eastern and South Eastern Arizona, to a lesser but still important degree in Central Arizona, and to a small degree in Yuma and along the Colorado Mainstem.

Arizona’s dairies and feed yards are a rapidly growing industry. These production facilities are also vulnerable to drought on Arizona croplands. The reliance of this industry upon crop producers and its associated vulnerability to long-term drought are discussed in the Dairies and Feed Yards Annex to Chapter II.

II. The Supply of Water to Arizona's Irrigated Agriculture

Sources of Supply

Irrigated agriculture in Arizona uses three primary sources of water. These are surface water from the Colorado River mainstem and CAP canal; surface water from other principal Arizona streams, of which the Gila, Salt-Verde, Agua Fria, and Santa Cruz River systems are the more important; and ground water. State law also recognizes two other water sources, so called 'in-lieu' water and effluent. Physical in-lieu water derives from CAP and effluent. Effluent was a supply source in only two responding districts. Locally occurring precipitation is of relatively minor importance over most of Arizona's more important irrigation districts, but for districts relying on surface water, precipitation on often distant watersheds is the original water source.

Use of surface water depends on flow volumes – which vary annually – and is governed by priority of claim or permit, as detailed on page 15 of the Operational Drought Plan. For those irrigating with surface water, vulnerability to drought in Arizona irrigated agriculture is importantly influenced by priority of use. In other words, the ability to irrigate with surface water would depend in large part on the volume of available water and on the priority rank of the user. Available volumes and priority rank are legal, institutional, physical, and hydrologic in nature.

Use of ground water depends on location, specifically whether or not the use (point of diversion) is located within one of the State's five active management areas (AMA's). For those irrigating with ground water at this writing, vulnerability to drought is related more to physical and hydrologic factors than to legal and institutional ones. There is discussion of groundwater management in Arizona on pages 13 – 15 of the Operational Drought Plan.

Concerning individual growers, or groups of growers, who irrigate and are located inside of irrigation districts, some use only district supplies, some use both district supplies and their own individual wells, and some use only their own individual wells. When district supplies are curtailed, for example by drought, individual growers may replace district supplies by increasing their private ground water withdrawals, to make a full complement of water.

An important amount of irrigated Arizona agriculture relies on ground water withdrawn by individual growers, who may or may not also have access to irrigation district supplies. At this writing, in general, for those individual growers irrigating with ground water withdrawn from their own wells, vulnerability to drought is primarily related to the same physical and hydrological limits faced by wells owned, leased, or operated by irrigation districts. Ground water for irrigated agricultural use by individual pumpers is an important water source in Eastern and South Eastern Arizona, to a lesser but still important degree in Central Arizona, and to a small degree in Yuma and along the Colorado Mainstem.

Classification of Irrigation Districts by Geographic Location and Water Sources as Reported by Irrigation District Managers

The survey asked for the approximate number of acre feet the district delivered[1] to irrigated agriculture in years 2000 and 2001 (this survey section is reproduced in an Annex to Chapter II in the full Work Group Report). It then asked about what percentage of district supplies came from each of six sources during those baseline years and during 2003. Finally, the survey asked managers to look out a dozen years, and indicate how they thought district supply sources might change. The water supplies of interest were those of the irrigation district, not those of individual growers or groups of growers within the district. This survey information is presented on Table 1.

The survey permits a classification of irrigation districts by the number of water sources available to the district, by their geographic location, and by their baseline volumes delivered. The six water sources are: CAP; other Colorado River water (mainstem Colorado); non-CAP surface water; district ground water; in-lieu; and other. These last two categories consist entirely of effluent or CAP surface water delivered in-lieu of ground water pumping.

Responding Districts that Rely Solely on Colorado River Mainstem Surface Water with Priority[2] 1, 2, or 3 Rights

Four Yuma County irrigation districts in this category responded to our survey: Unit "B", Wellton-Mohawk, Yuma ID, and Yuma County Water Users Association. Together, the four delivered just under 750,000 acre feet (af) of irrigation water in both baseline years (Table 1). These four districts all enjoy senior water rights to their mainstem Colorado River water (see the Chapter II Annex by Don Pope). The senior rights greatly limit the vulnerability of these districts to hydrologic drought. Other Yuma County districts also hold senior Colorado River rights, as do several mainstem Colorado River Indian Tribes.

Responding Districts that Rely Entirely or Almost Entirely on CAP and In-Lieu Supplies – No District-Delivered Ground Water

Four irrigation districts in this category responded to our survey. Harquahala Valley IDD, Tonopah ID, New Magma IDD, and Hohokam IDD are all located in Maricopa and Pinal Counties. Together, these four delivered about 283,000 and 274,000af of irrigation water in the baseline years. These four districts (as opposed to their individual growers) are

---

[1]. Both the survey and the Work Group are concerned with water deliveries, not with consumptive use or some other measure of water volumes.

[2]. For a discussion of priorities to Colorado River and other surface water supplies, see the Background Document in the full Task Force Report.

RIGATION DISTRI	CO.	Normal' AF Delivered 2000	Normal' AF Delivered 2001	Mainstem Col Norm	Mainstem Col 2003	Mainstem Col 015	CAP Norm	CAP 2003	CAP 015	In Lieu Norm	In Lieu 2003	In Lieu 015	Non-CAP Sura Norm	Non-CAP Sura 2003	Non-CAP Sura 015	District Groun Norm	District Groun 2003	District Groun 015	Other Source Norm	Other Source 2003	Other Source 015	Total Norm	Total 2003
Gila Valley Irrigatio	Gila	0	0																			**0**	**0**
McMullen Valley	LaP	0	0																			0	0
Harquahala Valle	Mar	100497	93867				100	100														100	100
Hyder Valley Irri	Mar	4	4													100	100	M				100	100
Maricopa Water I	Mar	60144	55257								40	L	60	40		40	20	M				100	100
New State Irrigat	Mar	907	527										71	50	L	29	50	L				100	100
Roosevelt Irrigat	Mar	169063	166732													80	80		20	20		100	100
Salt River Projec	Mar	152916	146278				14	10	L	19	22	L	45	29	M	22	39	L			M	100	100
San Tan Irrigatio	Mar	3525	2919													100	100					100	100
Tonopah Irrigati	Mar	14514	15056				46	37	L	54	63	M										100	100
Paloma Irrigation	Mar	136936	138153											15	L		85	M				0	100
Roosevelt Water	Mar	98043	98836							82	50	L			M	18	45	L	0	5	M	100	100
New Magma Irrig	M-P	92995	90603				47	53	L	53	47	L										100	100
Cortaro-Marana I	Pim	35000	32000				8	8	L				50	50		42	42					100	100
Central Arizona I	Pin	233167	221261				60	55	L							40	45	M				100	100
Hohokam Irrigati	Pin	75023	74027				30	54	M	70	46	L										100	100
Maricopa-Stanfie	Pin	230333	242366				46	51	L	19	5	L				35	44	M				100	100
San Carlos Irriga	Pin	39307	73378				7	12	M				60	18	M	33	70	L				100	100
Hilander "C" Irrig	Yum	0	0																			0	0
Unit "B" Irrigatio	Yum	28606.1	26617	100	100																	100	100
Wellton-Mohawk	Yum	400000	400000	100	100																	100	100
Yuma Irrigation I	Yum	62102	60036	100	100																	100	100
Yuma County Wa	Yum	249432	238783	100	100																	100	100
Totals		**2182514**	**2176700**																			0	0

Volumes delivereed are in acre-feet. The survey referred to the years 2000 & 2001 as 'normal' rather than baseline.

Notes on Non-CAP Surface and 'Other' Water Sources:
MWD: Surface water from the Agua Fria system.
New State: Supplies delivered by SRP.
SRP: Surface water from the Salt-Verde system.
Paloma ID: Gila River water diverted at Gillespie Dam into the Gila Bend Canal; mostly 91st Ave. plant plus Buckeye IDD drainage. Paloma did not delive
CMIDD: Water withdrawn from wells constitutes all CMIDD supplies, except for CAP water.
SCIDD: Surface Water from Gila system.
RID: Other would be the 23rd Ave plant.

dependent solely on in-lieu[3] and CAP supplies (Table 1) with a junior priority[2]. In effect, these districts have no control over their water supplies, and are therefore among the most vulnerable districts to prolonged hydrologic drought on the Colorado River.

Most if not all individual growers (or groups of growers) in these districts have access to ground water from privately owned wells. In some districts, total volumes delivered from privately-owned wells may exceed volumes delivered by the district. Under most circumstances, if individual growers experience reduced deliveries of CAP or in-lieu supplies, they will increase ground water withdrawals, to deliver a full water supply.

Responding Districts that Rely on CAP Supplies (Including In-Lieu) and Also Deliver Ground Water

Central Arizona IDD, Maricopa-Stanfield IDD, and Roosevelt WCD responded to our survey. Together, they delivered about 562,000af of irrigation water in both baseline years. These districts can adjust the balance between surface and ground water supplies. District ground water is withdrawn from wells owned, operated, or leased by these districts (not individual growers or groups of growers). CAIDD and MSIDD balance ground water and Junior CAP surface water, augmented (in the case of CAIDD) by some in-lieu water. RWCD combines in-lieu and ground water. There are no grower-controlled wells in either CAIDD or MSIDD.

To deliver full supplies in 2003, these districts all increased ground water withdrawals, as supplies to agriculture of CAP and in-lieu water decreased. Because of this ability to substitute ground water for surface water, at least to some degree, these districts are somewhat less vulnerable than those districts relying solely on CAP and in-lieu supplies. However, reliance on increased ground water withdrawals is associated with other vulnerabilities, discussed below.

Responding Districts that Rely on Non-CAP Surface Water and Also Deliver Ground Water

Five districts in this category responded to our survey. Maricopa WD, New State IDD, SRP, Cortaro-Marana ID, and San Carlos IDD are located in Maricopa, Pima, and Pinal Counties. Together they delivered about 288,300 and 307,440 af of irrigation water in the baseline years. To varying degrees, these districts can balance surface and ground water supplies. District ground water is withdrawn from wells owned, operated, or leased by these districts (not individual growers or groups of growers). Most surface water comes from the Agua Fria, Verde, Salt, Santa Cruz, and Gila River systems augmented to a relatively minor degree by CAP (including in-lieu).

Because of a greater relative balance in their water sources, these districts are generally somewhat less vulnerable to long-term hydrologic drought than those relying exclusively on CAP supplies, but more vulnerable than the high priority mainstem Colorado River

---

[3]. In-lieu supplies derive from either CAP or effluent.

districts. Recent widely fluctuating surface water supplies have increased the vulnerability to long-term hydrologic drought in several of these districts.

Individual growers (or groups of growers) who experience reduced district deliveries may also have access to ground water from privately owned wells and may increase private ground water withdrawals. In 2003, this did occur, as a result of highly fluctuating surface water supplies in principal Arizona streams.

Responding Districts That Rely on Ground Water for at Least 80% of Supplies

Six responding districts rely on ground water for 80 to 100% of their irrigation water supplies. McMullen Valley IDD, Hyder Valley Irrigation and Water Delivery District, Hilander 'C' IDD, Roosevelt ID, Paloma IDD, and San Tan ID are geographically dispersed throughout Maricopa, La Paz, and Yuma Counties. Together, these six delivered about 309,500 and 307,800 af of irrigation water in the baseline years. Hilander 'C' and McMullen Valley IDD do not deliver water, rather growers there irrigate with water withdrawn from their own privately owned wells. Hyder Valley is very small, delivering just 4 af of water in each of the baseline years of 2000 and 2001.

Approximately 80% of RID's water supply is withdrawn from district-owned wells. The remaining 20% is 'other' water, in this case effluent from the 23rd avenue plant. Approximately 85% of Paloma IDD's water supply is withdrawn from district-owned wells. The remaining 15% is Gila River surface water diverted into the Gila Bend Canal at Gillespie Dam. The source of this surface water is effluent from the 91st Ave plant and may include Buckeye WCDD drainage. The ability of these districts to substitute between water sources is limited by their high reliance on ground water. The vulnerability of these districts, and the growers within them who also irrigate with privately-owned wells, will depend on physical and hydrologic factors, such as well yield, depth to water, and volumes available for withdrawal.

Eastern and South Eastern Arizona

The GVID encompasses about 35,500 acres, most of which are cropped annually. The GVID does not deliver water, but represents ten different canal companies within the District. The canal companies deliver water to farmers who also irrigate with privately owned wells. Some canal companies also own wells. Surface water rights in the Safford area are authorized through the Gila River Decree. Gila River surface water is allocated to the canal companies in accordance with the Decree. During most of the preceeding five years, little or no Gila River surface water has been allotted, therefore, virtually all recent irrigated agriculture in the Safford valley has relied on ground water, whether withdrawn from individually-owned wells, or by the canal companies.

The Sulphur Springs Valley encompasses approximately 60,000 acres and includes agricultural areas south of the Safford Valley, including the Bonita area and Willcox to Douglas. The region has no permanent sources of surface water, thus the development of irrigated agriculture has completely relied on groundwater from the Willcox and Douglas basins. The Willcox basin occupies the northern three-fifths of the valley and covers approximately 1,911 square miles. It is the largest source of groundwater with an estimated 45.3 million acre-feet of groundwater stored to 1,2000 feet (ADWR 1994b).Within this basin the average well depth is 450 feet, but depths may vary from 100 feet in relatively shallow aquifers up to 700 feet in such areas as Kansas Settlement (Clark and Dunn 1997). The Douglas basin occupies the southern two-fifths of the valley and contains approximately 750 square miles. It has an estimated 32 million acre-feet of groundwater stored at 1,200 feet (ADWR 1994a). The principal source of groundwater recharge for the basins is winter precipitation, including snowmelt from the surrounding mountain ranges, which is transported to the valley by streams and washes (Mann et al. 1978).

Trends in Sources of Irrigation Water Supplies

The survey – and our other data sources – allow an assessment of two types of trends:

- Did supply sources change in 2003, as compared to the 2000-2001 baseline; and
- Do managers anticipate that supply sources are likely to change over the next dozen years?

Effect of Drought: Changing Supply Sources in 2003 – Increasing Agricultural Reliance on Ground Water

Among the eight responding districts relying on balance between surface and ground water, our responding district managers reported a clear trend toward increased reliance on ground water and decreased reliance on renewable surface water supplies in 2003. (Table 1 – SRP, RWCD, CAIDD, MSIDD, SCIDD, and New State). This trend was prompted by increasing demands on and reduced availability of surface water supplies, as a direct result of drought.

Anticipated Changes in Agricultural Water Sources towards 2015 – Increased Reliance on Ground water

Looking at the '2015' columns on Table 1, responding district managers expect greatly reduced reliance on CAP and in-lieu supplies by that time. The responding managers expect to pump more ground water to replace those surface supplies. The only districts anticipating less reliance on ground water by 2015 – SCIDD, RWCD, SRP, and New State – have already reduced surface water deliveries and increased ground water withdrawals because of drought. By 2015, these districts may be expecting a return to baseline surface flows, which would allow them to pump less ground water.

A Note on Ground Water Withdrawals and the Vulnerability of Irrigated Agriculture to Long-Term Drought

Wells are an important source of water to Arizona's irrigated agriculture and can provide some insulation against shortages caused by drought. At the same time, long-term drought may expose irrigators using ground water to increased vulnerability from several sources. Water tables may decline. This may affect well yield, and will increase the cost of pumping as more electricity will be required to lift the same amount of water. Drought has already affected the quantity of electricity generated and this threatens to reduce power supplies and increase power costs. Some wells may have been idle or infrequently used for long periods of time. Experience shows that such wells may require often costly rehabilitation before they again become fully productive. Finally, in most districts, it is physically impossible to serve all district lands from every well.

Chapter II Annex

Water Allocations and Priorities

By

Don Pope, Manager
Yuma County Water Users' Association

Water Allocations and Priorities

By: Don Pope, Manager
Yuma County Water Users' Association

To understand and discuss the Yuma area's water allocations and priorities, one must first understand the origin of the Lower Colorado River's allocations and the State of Arizona's entitlements.

A BRIEF HISTORY

The Colorado River Compact was signed at Sante Fe, New Mexico on November 24, 1922. Six of the seven basin states (California and Nevada in the Lower Basin and Wyoming, Colorado, Utah and New Mexico in the Upper Basin) ratified the Compact in 1923. Arizona did not ratify it until 1944. The Compact apportioned in perpetuity to the Upper and Lower Basins, respectively, the exclusive use of 7.5 million acre-feet of water per annum. The Compact further provided that the Upper Division would not cause the flow of the river at Lee Ferry (the division point of the Upper and Lower Divisions) to be depleted below an aggregate of 75,000,000 acre-feet for any ten consecutive years. In addition, it also recognized that Mexico could receive water.

The Boulder Canyon Project Act (Public Law No. 642 - 70th Congress H.R. 5775) of December 21, 1928, which authorized the construction of Boulder (Hoover) Dam, Imperial Dam and the All American Canal, also authorized the three Lower Basin states to enter in an agreement such that Nevada be apportioned 300,000 acre-feet and Arizona 2,800,000 acre-feet. This left 4,400,000 acre-feet for California.

In 1952, a suit was filed by Arizona against California to determine the legal water entitlements for the two states, when Arizona attempted to get authorization for the Central Arizona Project. The end result was a Supreme Court opinion on June 3, 1963 and a Supreme Court Decree dated March 9, 1964, which confirmed the Lower Basin entitlements established in the Boulder Canyon Project Act.

THE YUMA AREA'S COLORADO RIVER ENTITLEMENTS AND PRIORITIES

A complete listing of Arizona Entitlements and Priorities for the Colorado River with bullets placed by those in the Yuma area is provided at Attachment 1. The listing provides both contract numbers and dates. The actual water entitlements have been apportioned in different manners which somewhat complicates an overall summary. Some of the contracts are for diversions from the river, others are for consumptive use which give credit for water placed back in the river (diversions less return flows). And some contracts are for both, particularly when Present Perfected rights are involved. Further, some such as the Yuma County Water Users' Association (YCWUA) are unquantified beneficial use water rights certificates owned by the individual land owner and can only be estimated here.

Present Perfect Rights (PPRs) are those that predate the Boulder Canyon Project Act of 1928. PPRs have Priority 1 standing. These rights are the very most secure on the river. The Second (Federal) and Third Priorities follow with equal priority. These are priorities for contracts which predate the Colorado River Basin Project Act (CRBPA) of September 30, 1968, which authorized the construction of the Central Arizona Project (CAP). Attachment 2 is a page from the Act which contains the sentence which best denotes the seniority of the vast majority of our water over that of the CAP. Also provided at Attachment 3 is a page from a more recent Reclamation contract which provides a more detailed explanation of Colorado River priorities within the State of Arizona.

A summary of Yuma area legal entitlements and priorities extracted from the Attachment 1 listing, with estimated diversions for the YCWUA and Unit B's unquantified water rights certificates that are in addition to their PPRs:

	Diversions (ac-ft)	Consumptive Use (ac-ft)
Priority 1 (PPRs)	296,061	1,478
Priority 2 & 3	148,147 (est)*	576,522
Total Priority 1-3 (Pre-dates CAP)	**444,208**	**578,000**
Priority 4	16,320	-
Total Priority 1-4	460,528	578,000

* (Note: Used 116,000 and 20,000 acre-feet for YCWUA & Unit B respectively)

Actual diversions in the Yuma area for past years are as follows:

YEAR	ACTUAL DIVERSIONS (AC-FT)
2000	1,150,629
2001	1,150,782
2002	1,207,201

CONCLUSION

The Yuma area has nearly one-third of the State of Arizona's 2,800,000 acre-feet water entitlement on the Colorado River. Further, the seniority of the Yuma area water rights based on the "Law of the River", in particular the specific documents listed above, provide Yuma with the most secure water entitlements on the Colorado River. **It can be argued that Yuma has the most secure, most drought proof water supply in Arizona of all users of Colorado River water.** It is, however, a valuable resource that cannot be taken for granted and constant vigilance is required to maintain our water and its seniority.

(Note: The 3 attachments referred to are not included here, but are available from the YCWUA.)

III. The Vulnerability Of Arizona Irrigated Agriculture To Long-Term Drought

Our statewide survey of irrigation district managers asked two sets of questions about the vulnerability of irrigation districts to drought (see Chapter II Survey Section Annex). A Vulnerability To Long-Term Drought section – Roman Numeral II on the survey – asked about eighteen circumstances that might make the irrigation district vulnerable to drought. Survey responses permit a ranking of the eighteen circumstances, first in the 2003 drought year, and then supposing the current drought were to deepen into 2005 or 2006. Data from the survey section dealing with vulnerability to long-term drought is shown on Table 2 – Long-Term Drought Vulnerability Circumstances As Reported By Irrigation District Managers.

Twenty-two district managers responded. Together, these irrigation districts are located throughout Yuma, La Paz, Maricopa, Pinal, and Pima counties, and delivered about 2.18 million acre-feet (mmaf) of water to irrigated agriculture in each of the baseline years of 2000 and 2001.

Arizona's dairies and feed yards are a rapidly growing industry. These production facilities are also vulnerable to drought on Arizona croplands. The reliance of this industry upon crop producers and its associated vulnerability to long-term drought are discussed in the Dairies and Feed Yards Annex to Chapter II.

Survey Results – What Irrigation District Managers Say About District Vulnerability to Long-Term Drought

Summary of Results

Our survey listed eighteen circumstances that might make the irrigation district vulnerable to drought, either in the current 2003 situation or if the drought were to deepen into 2005 or 2006. Table 3 summarizes the results.[1]

Table 3. Summary of Survey Results – Vulnerability Circumstances

Absolute Rank *by total number indicating in 2003 and 2005/06*					Delta Rank *by number in 2005/06 minus number in 2003*		
	2003		2005/06				
Vulnerability Circumstance *(n = 22[1])*	How many mgrs. *(no.[2])*	How much water *(maf[3])*	How many mgrs. *(no.[2])*	How much water *(maf[3])*	Vulnerability Circumstance *(n = 22[1])*	Delta *(no.[2])*	How much water *(maf[3])*
Single water source	8	1026	12	1553	Severe supply shortage	7	759
Lack of/inadequate storage	7	777	8	915	Lack of preparedness	5	517
Wide precip. variation	7	440	8	783	Single water source	4	527
High growth affecting supply	6	541	6	582	Sudden change in supply	4	483
Low priority water rights	4	417	6	728	Low water supply reliability	3	304
Low water supply reliability	4	212	7	516	Imported water supply	3	
Sudden change in supply	3	264	7	747	Uncertain/low power supply	3	265
No political will to act	3		2		Low priority water rights	2	311
Uncertain/low power supply	2	85.3	5	350			
Severe supply shortage	1	56.3	8	815			
Lack of planning/preparedn's	1	27.6	6	545			

1. All 22 responding managers indicated one or more vulnerability circumstances.
2. The number of managers who indicated the circumstance.
3. Thousand acre feet delivered by the districts during the baseline period, (2001 + 2002)/2.

[1]. The one survey from eastern and south eastern Arizona is not included here, but is discussed separately at the end of this chapter.

This information is summarized under a discussion of three questions:

1. In 2003, which were the more important irrigation district drought vulnerabilities, in terms of both the absolute number of districts and the volumes of water delivered? How did this vary by geographic location, sources of water, and priorities over water use?

2. Which vulnerabilities might irrigation districts be most exposed to if the current drought continues into 2005 or 2006?

3. Are trends in the vulnerabilities of irrigation districts to drought evident between 2003 and 2005/6, assuming the current drought continues?

The Work Group notes that most responding managers completed the survey between October-December, 2003, before it became evident that the drought would continue through 2004 and perhaps beyond. The availability of in-lieu water supplies also decreased in 2003. At least one manager noted that survey responses might change if the survey were held today (See Annex, "All Comments Made By Survey Respondents"):

Irrigation District Vulnerability To Drought in 2003

Looking at drought during 2003, vulnerability to a ***single water source*** was the most frequently experienced drought vulnerability and cut across all counties, water sources, and surface water priorities responding.

In 2003, a tie for second occurred among two characteristics: Lack of or inadequate ***water storage***, and ***widely varying precipitation***. The concern over ***storage*** was more concentrated among district managers relying on the Colorado River (including CAP users), perhaps reflecting current reservoir levels in Lakes Mead and Powell. Concern with ***widely varying precipitation*** seemed of greatest concern among districts who depend significantly on surface water supplies, including those using all of Arizona's principal streams. Locally occurring precipitation is of relatively minor importance over most of Arizona's more important irrigation districts, but for districts relying on surface water, precipitation on often distant watersheds is the original water source.

Vulnerability ***to high additional demand*** resulting from high growth was the fourth-most frequent vulnerability circumstance mentioned, and this vulnerability was more concentrated among districts located on the urban fringes of Yuma, the southeast and southwest Phoenix valley, and north Tucson. Because surface water supplies from principal Arizona streams were reduced in 2003 by drought and unusually hot weather, demand increased for CAP supplies.

Tied for the fifth-most frequent 2003 vulnerability were two more characteristics: ***low water supply reliability***, and ***low priority water/contractual rights***. The concern over ***low***

reliability was evident among districts that use widely fluctuating surface water supplies and junior non-Indian agricultural pool CAP users. In 2003, ***low priority rights*** were of concern in districts relying extensively on junior CAP rights.

Irrigation District Vulnerability if the Present Drought Continues Into 2005 or 2006

A second question concerned vulnerabilities that irrigation districts might be exposed to if the current drought were to continue into 2005 or 2006, again considering the absolute number of districts, the volumes of water delivered, geographic location, sources of water, and priorities over water use.

In general, district managers indicated exposure to a greater number of vulnerabilities if the drought were to continue for two or three more years. While 2005/06 and 2003 showed many of the same vulnerabilities, district managers did expect some new concerns if the drought deepens.

As district managers assessed the possibility of the current drought deepening into 2005 or 2006, vulnerability to a ***single source*** of supply was also of greatest concern across all geographic locations, sources of water, and surface water priorities. Referring to Table 1, it is noteworthy that 9 of the 22 responding districts relied on a single source for all of their irrigation water, and three more districts relied on one source for at least 80% of their supplies. When combined with the statistical information related to trends anticipated in 2015 water supply sources (Table 1), we can see that the prospect of a prolonged drought is causing district managers to anticipate a decreased reliance on surface water and an increased reliance on ground water.

The prospects of a ***severe supply shortage***, lack of or inadequate ***water storage***, and ***widely varying precipitation*** tied as the second highest concerns if the present drought were to continue into 2005/6. Concern that a ***severe supply shortage*** might develop by 2005/6 was spread across geographic areas, water sources, and surface water right priorities, but was not among the leading vulnerability characteristics mentioned by district managers in 2003. Concern about ***storage*** was more concentrated among responding senior and junior Colorado River users. Districts concerned about ***widely varying precipitation*** included those using all of Arizona's principal streams: the Colorado (whether senior or junior right holders), Agua Fria, Salt-Verde, Gila, and Santa Cruz Rivers. Locally occurring precipitation is of relatively minor importance over most of Arizona's more important irrigation districts, but for districts relying on surface water, precipitation on often distant watersheds is the original water source.

Tied for the fifth-most frequent 2005/06 vulnerability were ***low water supply reliability***, the prospect of a ***sudden change*** in supply, and ***high additional demand*** resulting from urban growth. As in 2003, ***Low reliability*** concerned managers depending on widely fluctuating surface water and junior CAP supplies. The prospect of a ***sudden change*** concerned districts that rely on Colorado River water and widely fluctuating surface supplies from the Agua Fria and Gila Rivers.

Anticipated Trends between 2003 and 2005 or 2006, if the Drought Continues

Finally, we asked whether trends in the vulnerabilities of irrigation districts to drought were evident. Trends between 2003 and 2005/6 were assessed by subtracting the number of managers indicating a vulnerability circumstance in 2003 from the number of managers indicating the same circumstance in 2005/6. The circumstances were then ranked, with the largest number receiving the highest rank (Table 3 – Delta Rank).

The increase in concern over a potential ***severe shortage*** – from one to eight district managers – was the largest increase in concern with any drought vulnerability characteristic and was spread across geographic areas, water sources, and surface water right priorities. About two in five district managers may anticipate their water supply situations to seriously worsen if the current drought were to continue for even two or three more years.

The increase in concern over a lack of ***drought planning and preparedness*** that may develop over the 2003 to 2005/6 period – from one to six district managers – was the second-largest increase in concern with any drought vulnerability characteristic. This concern was spread across geographic areas; districts relying on ground water, the Colorado and other surface water sources; both junior and senior right-holders; and volumes delivered. One interpretation of this information might be that more than one in four of our responding district managers attach importance to advance early warning: They would like to see a developing problem coming as far in advance as possible. Because a number of districts already have – and indeed, are implementing – contingency plans for dealing with district-level supply shortages, a second interpretation might be support for Statewide drought planning.

Concerns over dependence on ***single supply*** sources ranked first in both 2003 and 2005/06, and the *increase* from 2003 to 2005/6 in the number of managers and volume of deliveries indicating concern with this circumstance tied for the third-largest vulnerability trend. To the degree that this trend may also be associated with a decreased reliance on surface water and an increased reliance on ground water, the set of specific vulnerability circumstances may change but overall vulnerability may further increase.

Vulnerability to ***sudden changes in supply*** was the other third place trend. CAP users experienced intensifying competition for water in 2003, and may be anticipating more of the same if the drought continues. This would lead to increasing vulnerability, the more so if the availability of other surface sources continues to diminish.

By 2005/06, ***Power supplies*** may become less certain and power supplies may fall. At the same time, power demand and unit power costs both may rise. These eventualities are likely to increase the total expenditure on power, whether at district or individual grower level.

The next section summarizes detailed information on vulnerability circumstances for the current (2003) situation, the possibility that the drought continues into 2005 or 2006, and evident trends. A detailed discussion of the more significant individual vulnerability circumstances follows, with the vulnerability circumstance most often mentioned discussed first. All data in following sections is based on Tables 1 and 2.

District Vulnerability to a Single Water Source

Vulnerability to reliance on a single water source was the most frequent circumstance mentioned. Eight (36%) of the 22 responding district managers said their district was vulnerable to reliance on a single water source during 2003. These numbers rose to twelve and 55% if the current drought were to continue into 2005 or 2006. In 2003, these districts delivered more than half of the 2.180 million total acre-feet delivered among all 22 responding districts during the baseline 2000-2001 period, and 71% of total baseline deliveries if the drought were to continue for two or three more years. Interestingly, districts indicating vulnerability to a single source cut across all counties, water sources, and surface water priorities responding.

Trend

The increase from 2003 to 2005/6 in the number of managers and volume of deliveries indicating concern with vulnerability to a single water source – from 8 to 12 managers and about 1.03 to 1.55 mmaf – represented the third-largest increase in vulnerability to any circumstance on the survey. When combined with the statistical information related to trends anticipated in 2015 water supply sources (Table 1), we can see that the prospect of a prolonged drought is causing district managers to anticipate a decreased reliance on surface water and an increased reliance on ground water. If this were to occur, the risks associated with reliance on ground water previously noted – increasing depth to water, increasing costs, electricity supply problems, etc. – might also increase.

District Vulnerability To A Single Water Source

Characteristic (*n = 22*)	2003 How many managers	2003 Baseline volume (1000af)[a]	2003 P - S[b]	2005-2006 How many managers	2005-2006 Baseline volume (1000af)[a]	2005-2006 P - S[b]
Single W. Source	8 - 36%[c]	1026-47%[c]	-	12 – 55%[c]	1553-71%[c]	-
Yuma	3	672 (31%)	Sr – CrM	4	733 (34%)	Sr – CrM
Maricopa & Pinal	4	186 (9%)	Jr – CP[d]	6	515 (24%)	Jr – CP,gw[d]
Maricopa	1	168 (8%)	gw, o	2	305 (14%)	sw, gw, o

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project

gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
22 district managers responded, so 8/22 = 36%
baseline 2000 & 2001 deliveries were 2,179,607 af, so 1026/2179.6 = 47%
Percentages may not add due to rounding errors.

d. Except Hyder Valley IWDD.

Lack of or Inadequate Water Storage

Vulnerability to a lack of or inadequate water storage tied for the second-most frequent circumstance among our responding district managers. Seven (32%) of the 22 responding district managers said their district was vulnerable to a lack of or inadequate water storage during 2003. These numbers increased to eight and 36% if the current drought were to continue into 2005 or 2006. In 2003, these districts delivered over one-third or 0.777 of the 2.081 mmaf total delivered among all 22 responding districts during the baseline 2000-2001 period. This rose to 0.915 mmaf and 42% of total baseline deliveries if the drought were to continue for two or three more years. This vulnerability was more concentrated among responding senior and junior Colorado River users, perhaps reflecting currently dwindling storages on the River.

Lack Of Or Inadequate Water Storage

Characteristic (*n = 22)*	2003			2005-2006		
	How many managers	'Baseline' volume (1000af) [a]	P - S [b]	How many managers	'Baseline' volume (1000af) [a]	P – S [b]
Lack of Storage	7 - 32% [c]	777– 36% [c]	-	8 - 36% [c]	915– 42% [c]	-
Yuma	2	272 (12%)	Sr – CrM	2	272 (12%)	Sr – CrM
Maricopa & Pinal	4	278 (13%)	Jr – CP	4	278 (13%)	Jr – CP
Pinal	1	227 (10%)	gw,Jr-CP	1	227 (10%)	gw,Jr-CP
Maricopa	-	-	-	1	138 (6%)	gw, sw

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
22 district managers responded, so 7/22 = 32%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 777/2,179.6 = 36%
Percentages may not add due to rounding errors.

Wide Precipitation Variation

Wide precipitation variation tied for the second-most frequent vulnerability circumstance mentioned. Seven (32%) of the 22 responding district managers said their district was vulnerable to wide precipitation variation during 2003. These numbers rose to eight and 36% if the current drought were to continue into 2005 or 2006. In 2003, these districts delivered about twenty percent or 0.440 of the 2.180 mmaf total delivered among all 22 responding districts during the baseline 2000-2001 period. However, the vulnerable volume delivered increased by eighty percent, to 0.783 mmaf and 36% of total baseline deliveries if the drought were to continue for two or three more years. This vulnerability seemed to concern districts who depend significantly on surface water supplies. As noted in the Chapter Introduction, locally occurring precipitation is of minor importance over most of these districts, but precipitation on the watershed is the original source of surface flows. Varying precipitation on the watershed must translate into varying stream flows (and also varying storage volumes). Districts indicating this concern included those using all of Arizona's principal streams: the Colorado (whether senior and junior right holders), Agua Fria, Salt-Verde, Gila, and Santa Cruz Rivers.

Wide Precipitation Variation

Characteristic (*n = 22)*	2003			2005-2006		
	How many managers	Baseline volume (1000af) [a]	P - S [b]	How many managers	Baseline volume (1000af) [a]	P - S [b]
Wide Precip. Var'n	7 - 32% [c]	440-20% [c]	-	8 - 36% [c]	783-36% [c]	-
Yuma	1	27.6 (1%)	Sr – CrM	1	27.6 (1%)	Sr – CrM
Maricopa & Pinal	2	166 (8%)	Jr – CP	2	166 (8%)	Jr – CP
Maricopa & Pinal	1	98.4 (5%)	Jr-CP,gw	2	326 (15%)	Jr-CP,gw
Maric., Pinal, Pima	3	148 (6%)	sw, gw[d]	3	264 (12%)	sw, gw[d]

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
22 district managers responded, so 7/22 =32%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 439.9/2,179.6 = 20%
Percentages may not add due to rounding errors.

d. Districts also used annually varying small amounts – less than 10% of total supplies – of junior priority CAP water during at least one year between 2000 and 2003.

Severe Water Supply Shortage

Vulnerability to a severe water supply shortage was noted by only one district manager in 2003 and was not among the leading 2003 vulnerability characteristics noted by our district managers. However, if the drought were to continue into 2005 or 2006 eight managers whose districts delivered 37% of baseline volumes indicated vulnerability concerns, tying it for second place among vulnerability concerns in that later period.

Trend

The increase in concern that a severe shortage may develop over the 2003 to 2005/6 period – from one to eight district managers – was the largest increase in concern with any drought vulnerability characteristic. This concern was spread across geographic areas, water sources, and surface water right priorities. Three of these eight districts experience highly fluctuating surface supplies (MWD, from the Agua Fria; SRP from the Salt-Verde; and SCIDD, from the Gila). Four hold junior CAP priorities, three rely exclusively on these (Harquahala, NMIDD, and Hohokam). One interpretation of this information might be that almost 40% of our responding district managers may anticipate their water supply situations to seriously worsen if the current drought were to continue to deepen for even two or three more years.

Severe Water Supply Shortage

Characteristic (*n = 22*)	2003 How many managers	2003 Baseline volume (1000af)[a]	2003 P - S[b]	2005-2006 How many managers	2005-2006 Baseline volume (1000af)[a]	2005-2006 P - S[b]
SevereWSShortage	1 - 5%[c]	56.3 – 3%[c]	-	8 - 38%[c]	815–37%[c]	-
Yuma	-	-	-	1	61.1 (3%)	Sr – CrM
Maricopa & Pinal	1	56.3 (3%)	Jr–CP,gw sw	3	264 (12%)	Jr–CP,gw sw
Maricopa & Pinal	-	-	-	4	490 (23%)	Jr-CP,gw

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
1 district manager responded, so 1/22 = 5%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 56.3/2,179.6 = 3%
Percentages may not add due to rounding errors.

Lack of Drought Planning or Preparedness; Lack of Collaboration or Coordination with Others in Planning or Preparing for Drought; Lack of Data or Single Source of Data for Drought Forecasting and Planning

Our district manager survey included three circumstances involving vulnerability related to a lack of planning and preparing for drought. The three circumstances were:

- ✓ Lack of drought planning/preparedness
- ✓ Lack of collaboration or coordination with others in planning or preparing for drought
- ✓ Lack of data/single source data for drought forecasting and planning

In our tabulation, these three questions are combined, such that any manager and associated district water volume indicating concern with one or more of these three circumstances is counted only once.

Vulnerability to a lack of coordination, planning or preparing, or a lack of data for drought preparedness was noted by only one district manager in 2003 and so was not among the leading 2003 vulnerability characteristics. However, if the drought were to continue into 2005 or 2006 and during that time attention to planning and preparedness did not improve, six managers, representing 27% of baseline delivery volumes indicated concern with this characteristic.

Trend

The increase in concern if drought planning and preparedness did not improve over the 2003 to 2005/6 period – from one to six district managers – was the second-largest increase in concern with any drought vulnerability characteristic. This concern was spread across geographic areas; districts relying on ground water, the Colorado River and other surface water sources; both junior and senior right-holders, and volumes delivered. One interpretation of this information might be that more than one in four of our responding district managers attach importance to advance early warning: They would like to see a developing problem coming as far in advance as possible. District managers may be indicating a need for better forecasting, in light of concerns already discussed over single sources of water supply, widely fluctuating precipitation, inadequate storage, and severe supply shortages.

Lack Of Coordination, Planning, Data For Drought Preparedness

Characteristic (*n = 22*)	2003 How many managers	2003 Baseline volume (1000af) [a]	2003 P - S [b]	2005-2006 How many managers	2005-2006 Baseline volume (1000af) [a]	2005-2006 P - S [b]
Lack of Prepared's	1 - 5% [c]	27.6 – 1% [c]	-	6 - 27% [c]	545-25% [c]	-
Yuma	1	27.6 (1%)	Sr-CrM	2	88.7 (4%)	Sr – CrM
Maricopa & Yuma	-	-	-	2	138 (6%)	gw
Maricopa & Pinal	-	-	-	2	319 (15%)	Jr-CP,gw

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
1 district manager responded, so 1/22 = 5%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 27.6/2179.6 = 1%
Percentages may not add due to rounding errors.

d. Three survey questions dealing with planning, coordination, and data for forecasting and preparedness were included on the survey, leading to some redundancy in survey design. In our tabulation, these three questions are combined; managers and water volumes in each responding district are counted only once.

High Growth Area or High Additional Demand (Urban Growth Affecting Irrigation Supply)

District managers were asked whether urban growth was affecting their irrigation water supplies, and vulnerability to high additional demand resulting from high growth was the fourth-most frequent vulnerability circumstance mentioned. Six (27%) of the 22 responding district managers said their districts were vulnerable to urban growth affecting the irrigation water supply. In 2003, these districts delivered 25% or 0.541 of the 2.180 mmaf total delivered among all 22 responding districts during the baseline 2000-2001 period. The number of managers remained constant if the current drought were to continue into 2005 or 2006, but the volume of baseline deliveries affected increased slightly to 27%. Not surprisingly, this vulnerability was more concentrated on the urban fringes of Yuma, the southeast and southwest Phoenix valley, and north Tucson.

High Growth Area/High Additional Demand (Urban Growth Affecting Irrigation Supply)

Characteristic (*n = 22)*	2003			2005-2006		
	How many managers	Baseline volume (1000af) [a]	P - S [b]	How many managers	Baseline volume (1000af) [a]	P - S [b]
High Growth/D	6 - 27% [c]	541–25% [c]	-	6 – 27% [c]	582-27% [c]	-
Yuma	1	244 (11%)	Sr-CrM	1	244 (11%)	Sr – CrM
Maricopa & Pinal	1	92 (4%)	Jr – CP	2	166 (8%)	Jr - CP
Maric.,Pima,Pinal	4	205 (9%)	gw, sw	3	172 (8%)	gw, sw

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
6 district managers responded, so 6/22 = 27%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 541.2/2179.6 = 25%
Percentages may not add due to rounding errors.

Low Water Supply Reliability

Vulnerability to low supply reliability tied for the fifth-most frequent circumstance mentioned. Four (18%) of the 22 responding district managers said their district was vulnerable to low supply reliability during 2003. These numbers rose to seven and 32% if the current drought were to continue into 2005 or 2006. In 2003, these districts delivered about 10% of the 2.180 million total acre-feet delivered among all 22 responding districts during the baseline 2000-2001 period, and about 25% of total baseline deliveries if the drought were to continue for two or three more years. These districts use widely fluctuating surface water supplies (from the Agua Fria and Gila rivers) and on junior CAP non-Indian agricultural pool water.

Trend
The increase between 2003 and 2005/6 – from four to seven managers and ten to twenty-four percent of 'normal deliveries – tied for fifth-largest increase in vulnerability to any circumstance on the survey. Like the concerns over severe shortages and dependence on single sources of supply, managers with less reliable supplies may be anticipating increased problems if the drought continues and surface water availabilities continue to decline over the next two to three years.

Low Water Supply Reliability

Characteristic (*n = 22*)	2003			2005-2006		
	How many managers	Baseline volume (1000af)[a]	P - S[b]	How many managers	Baseline volume (1000af)[a]	P - S[b]
Low Reliability	4 – 18%[c]	212–10%[c]	-	7 - 32%[c]	516-24%[c]	-
Maricopa & Pinal	1	97.2 (4%)	Jr – CP	3	264 (12%)	Jr - CP
Maric.,Pima,Pinal	3	115 (5%)	gw, sw	4	252 (12%)	gw, sw

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
4 district managers responded, so 4/22 = 18%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 211.9/2179.6 = 10%
Percentages may not add due to rounding errors.

Sudden Change in Water Supply

Vulnerability to sudden changes in supply tied for seventh among circumstances mentioned. Just three (14%) of the 22 responding district managers said their district was vulnerable to sudden supply changes during 2003. These numbers rose to seven managers and 32% if the current drought were to continue into 2005 or 2006, the third largest change. In 2003, these districts delivered about 14% of the 2.180 million total acre-feet delivered by all 22 responding districts during the baseline 2000-2001 period. If the drought were to continue for two or three more years, the seven districts indicating this circumstance delivered about 34% of total baseline deliveries.

All three districts indicating this vulnerability in 2003 rely entirely on junior CAP supplies, which in 2003 experienced increased demand. Because surface water supplies from principal Arizona streams were reduced in 2003 by drought and unusually hot weather, demand increased for CAP supplies. Looking at the 2005/6 survey responses, five of the seven districts that indicated vulnerability to sudden changes in water supply use Colorado River water to some degree, while two use widely fluctuating surface water supplies (from the Agua Fria and Gila rivers).

Trend

Colorado River users experienced intensifying competition for water in 2003, and may be anticipating more of the same if the drought deepens. This would lead to increasing vulnerability, the more so if the availability of other surface sources continues to diminish. Nevertheless, as indicated in the Chapter Introduction, when district surface water supplies are curtailed, for example by drought, individual growers and districts who also deliver ground water may replace district supplies by increasing ground water withdrawals, to make a full complement of water.

Sudden Change In Water Supply

Characteristic (*n = 22*)	2003 How many managers	2003 Baseline volume (1000af) [a]	2003 P - S [b]	2005-2006 How many managers	2005-2006 Baseline volume (1000af) [a]	2005-2006 P – S [b]
Sudden Change	3 - 14% [c]	264– 12% [c]	-	7 - 32% [c]	747– 34% [c]	-
Yuma	-	-	-	1	61.1 (3%)	Sr – CrM
Maricopa & Pinal	3	264 (12%)	Jr – CP	3	264 (12%)	Jr – CP
Pinal	-	-	-	1	227 (10%)	gw,Jr-CP
Maricopa	-	-	-	2	195 (9%)	gw, sw

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
22 district managers responded, so 3/22 = 14%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 264.2/179.6 = 12%
Percentages may not add due to rounding errors.

Low Priority Water/Contractual Rights

Vulnerability to low priority water or contractual rights tied for the fifth-most frequent circumstance mentioned. Four (18%) of the 22 responding district managers said their district was vulnerable to low priority rights during 2003. These numbers rose to six and 27% if the current drought were to deepen into 2005 or 2006. In 2003, these districts delivered about 19% or 0.417 of the 2.180 mmaf delivered among all 22 responding districts during the baseline 2000-2001 period, and about 33% of total baseline deliveries if the drought were to continue for two or three more years. In 2003, low priority rights were of concern in three districts relying extensively on junior CAP rights. Five of the six managers indicating that this circumstance would become a concern by 2005/6 also rely extensively on junior CAP rights. The increase between 2003 and 2005/6 – from four to six managers and nineteen to thirty-three percent of 'normal deliveries – was not among the largest changes in vulnerability – but the volume of water involved is significant.

Low Priority Water/Contractual Rights

Characteristic (*n = 22)*	2003			2005-2006		
	How many managers	Baseline volume (1000af) [a]	P - S [b]	How many managers	Baseline volume (1000af) [a]	P – S [b]
Low Priority	4 – 18% [c]	417– 19% [c]	-	6 - 27% [c]	728– 33% [c]	-
Maricopa & Pinal	2	189 (9%)	Jr – CP	3	264 (12%)	Jr – CP
Pinal	1	227 (10%)	gw,Jr-CP	2	464 (21%)	gw,Jr-CP
Maricopa	1	0.7 (0%)	gw,sw	1	0.7 (0%)	gw, sw

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
22 district managers responded, so 4/22 = 18%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 417/2,179.6 = 18%
Percentages may not add due to rounding errors.

Uncertain/Low Priority Power Supply

For 2003, vulnerability to uncertain or low priority power supply was noted by only two district managers representing just 4% of baseline deliveries. Five managers whose districts delivered 16% of baseline volumes indicated concern with this characteristic if the drought were to continue into 2005 or 2006. This vulnerability was not among the leading characteristics noted by our district managers for either period. However, the five managers indicating concern if the drought were to deepen represent both Yuma and Central Arizona, all sources of supply, and all use priorities.

Trend – A Note on Power and the Vulnerability of Irrigated Agriculture to Long-Term Drought

Increases in the number of district managers and the amount of baseline water volume vulnerable to uncertain or low priority power supplies are both noteworthy. A follow-up conversation with one manager of a water and power district suggests that warmer and dryer weather and a shift towards ground water as a supply source might increase district vulnerability to uncertain power supplies in the following ways. Many irrigation districts also supply power, which is often tied down using long-term supply contracts. Unit power prices under such long-term contracts are typically lower than spot prices. During drought, if reservoir levels fall, pumping increases, and water tables decline with increased use of ground water, less power might be generated at the same time as the demand for power rises. Power supplied under long-term contracts may have to be supplemented by more costly spot market purchases. Power supplies may become less certain. The net effect is that power demand and unit costs both may rise at the same time as power supply may be diminishing. This increases the total expenditure on power, whether at district or individual grower level.

Uncertain/Low Priority Water Supply

Characteristic (*n = 22)*	2003			2005-2006		
	How many managers	Baseline volume (1000af)[a]	P - S[b]	How many managers	Baseline volume (1000af)[a]	P - S[b]
High Growth/D	2 – 9%[c]	85.3–4%[c]	-	5 - 23%[c]	350-16%[c]	-
Yuma	1	27.6 (%)	Sr-CrM	1	27.6 (%)	Sr – CrM
Maricopa & Pinal	-	-	-	2	166 (%)	Jr - CP
Maricopa	1	57.7 (%)	gw, sw	2	156 (%)	Jr-CP, gw, sw

a. Baseline af delivered is defined as (2000 + 2001)/2, or 2,179,607 af, the average volume delivered by our 22 responding districts in 2000 and 2001.

b. P = Priority: Sr = Senior
Jr = Junior
S = Source: CrM = Colorado Mainstem
CP = CAP, or Central Arizona Project
gw = ground water
sw = surface water, effluent, or in-lieu
o = other (may be effluent)

c. The percentage of total response, whether of district managers or acre feet delivered:
2 district managers responded, so 6/22 = 9%
Baseline 2000 & 2001 deliveries were 2,179,607 af, so 350 /2179.6 = 16%
Percentages may not add due to rounding errors.

Other Vulnerability Circumstances

The survey asked about eighteen vulnerability circumstances, all but four are discussed in detail, above, or included on Table 3. The other four circumstances and the number of managers indicating them are shown in the table below.

Vulnerability Circumstance	How Many Managers '03	'05/06
Water supply at risk from contamination	0	2
Water supply is subject to other natural disasters	2	4
Threat ignored: no action until shortage became real	0	2
Non-interconnected water supply	1	2

Eastern and South Eastern Arizona

According to the manager of the Gila Valley Irrigation District, water supplies to irrigated agriculture in the Safford area are vulnerable to low reliability, sudden changes, periodic severe shortages, and contamination, all in turn related to natural disasters such as flooding and widely varying precipitation. Other vulnerability circumstances in the area include lack of drought forecasting, planning, preparedness, and data and low priority water/contractual rights. The District Manager noted only one trend if the drought continues, increasing reliance on a single water source. A number of irrigation wells in the Valley are relatively shallow. The service areas for shallow wells are expected to become more reliant on surface diversions as ground water levels decline in the face of continuing drought. However, surface diversions have been largely unavailable in recent years.

Since the 1970s, groundwater overdraft has been a major concern throughout the SSV region as more groundwater is being pumped than is being replenished by precipitation or other recharge. With long-term drought, the cost of water for farmers in the Sulpher Springs Valley has increased substantially, impacting the viability of irrigated farming. Pumped water from underground sources tends to be more expensive than surface water. Pumping costs are a function of water levels and of energy prices, so as water levels decline and the price of energy increases, the cost of groundwater irrigation goes up and with it the vulnerability of irrigated agriculture to long-term drought. As every farmer in the Sulpher Springs Valley knows, given the present drought, access to water presents the greatest challenge to the local farming industry, and those whose crops require more water tend to be more vulnerable. As drought lowers the water table, knowing if the dry winters will continue is the most important factor in deciding whether to continue farming or to leave the region.

Vulnerability to drought, however, is not only related to hydrologic and climatic conditions. Farmers rely on both vertical (institutional) and horizontal (social capital) networks to reduce their vulnerability. These formal and informal networks provide access to climate information and to financial and other assets that allow farmers to respond to drought and adapt. Some farmers, particularly those under disadvantaged socioeconomic conditions, have a more difficult time recovering from and adapting to drought

TABLE 2: Long-Term Drought Vulnerability Circumstances As Reported By Irrigation District Managers

IRRIGATION DIST	COU	AF Delivered			Lack of Dr		Lack of Co		Lack of da		Single Wa		Low Wate		Low Priori		Imported \		Severe su		Power Su		Lack of W		High grow		Sudden C		Wide prec		Water Sup		No politica	
		2000 AF	2001 AF	(00+01)/2	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6	03	05/6
McMullen Valley	LaPa	0	0	0																														
Harquahala Valle	Mari	100497	93867	97182							1	1	1	1	1	1				1			1	1			1	1				1		
Hyder Valley Irri	Mari	4	4	4							1	1																						
Maricopa Water I	Mari	60143.88	55257.06	57700.5									1	1				1		1	1	1						1	1	1				
New State Irrigat	Mari	907	527	717									1	1	1	1									1	1								
Roosevelt Irrigat	Mari	169063	166732	167898							1	1													1	1								
Salt River Projec	Mari	152916	146278	149597														1		1										1				
San Tan Irrigatio	Mari	3525	2919	3222																					1	1								
Tonopah Irrigatic	Mari	14514	15056	14785							1	1					1	1					1	1							1	1		
Roosevelt Water	Mari	98043	98836	98439.5																		1							1	1	1	1	1	1
Paloma Irrigatior	Mari	136936	138153	137545		1		1				1		1										1				1						
New Magma Irric	M-P	92995	90603	91799		1		1		1		1		1	1	1		1		1		1	1	1	1	1	1	1	1	1			1	1
Cortaro-Marana I	Pima	35000	32000	33500																					1				1					
Central Arizona I	Pina	233167	221261	227214		1		1		1					1	1				1			1	1				1		1				
Hohokam Irrigati	Pina	75023	74027	74525							1	1		1		1				1		1	1	1		1	1	1	1	1				
Maricopa-Stanfie	Pina	230333	242366	236350								1				1																		
San Carlos Irriga	Pina	39307	73378	56342.5									1	1					1	1									1	1				
Hilander "C" Irric	Yum	0	0	0						1																								
Unit "B" Irrigatio	Yum	28606.14	26617.15	27611.6	1		1		1	1	1	1					1	1			1	1	1	1					1	1			1	
Wellton-Mohawk	Yum	400000	400000	400000							1	1																						
Yuma Irrigation I	Yum	62102	60036	61069		1						1								1								1				1		
Yuma County Wa	Yum	249432	238783	244108							1	1											1	1	1	1								
Totals		**2182514**	**2176700.2**	2179607	**1**	**4**	**1**	**3**	**1**	**4**	**8**	**12**	**4**	**7**	**4**	**6**	**2**	**5**	**1**	**8**	**2**	**5**	**7**	**8**	**6**	**6**	**3**	**7**	**7**	**8**	**2**	**4**	**3**	**2**
Priority Rank: 2003 (by largest number of managers)											1		T - 5		T - 5								T - 2		4		T - 7		T - 2				T - 7	
Priority Rank:2005/6 (by largest number of managers)					T - 7						1		T - 5		T - 7				T - 2				T - 2		T - 7		T - 5		T - 2					

Four of the eighteen survey circumstances are not shown on this table. None of those four received more than two responses, whether in 2003 or 2005/2006.

Chapter III Annex

Irrigated Agriculture Survey Section I:
Statistical Information Pertaining To The District

and

Irrigated Agriculture Survey Section II:
Vulnerability To Long-Term Drought

IRRIGATED AGRICULTURE SURVEY
LONG-TERM DROUGHT PREPAREDNESS AND RESPONSE

I. STATISTICAL INFORMATION PERTAINING TO THE DISTRICT

Name of Irrigation District: ____

Address: ____

Phone: ____________________________ Fax: ______________________________

Email: ____

Contact: Name of Person who filled-in the questionnaire: ________________________

About how much water did your district deliver to irrigated agriculture in 2000 and 2001:
Acre-feet delivered to irrigated agriculture in 2000 ___________________af
Acre-feet delivered to irrigated agriculture in 2001 ___________________af

Please tell us about the *DISTRICT's* water supply sources, in percentage terms. About what percentage of *DISTRICT* supplies came from each source in normal (2000-2002) years and this year (2003)? As you look out a dozen years, to 2015 more or less, how do you think this might change? In your estimation, in percentage terms, are the *DISTRICT's* supplies from each source likely to be less or more than the 'normal' 2000-2002 period? Water supplies of interest are those of the Irrigation District, not those of individual growers or groups of growers within the District.

Water Supply Source	**Normal Source (2000-2002)**	**2003 Source**	**2015 Source**
CAP	%	%	□ Less □ More
Other Colorado River Water	%	%	□ Less □ More
Non-CAP Surface Water	%	%	□ Less □ More
District Ground Water	%	%	□ Less □ More
In Lieu	%	%	□ Less □ More
Other Source	%	%	□ Less □ More
Total	100%	100%	□ Less □ More

II. VULNERABILITY TO LONG-TERM DROUGHT

Below are some circumstances that may make the *DISTRICT* vulnerable to drought. We would like to know about vulnerability circumstances in the current year (2003), and also about how the *DISTRICT's* vulnerability to drought might change if the present drought continues to worsen for, say, two or three more years.

Please check all of the statements that fit the *DISTRICT's* current (2003) situation and also those you think would apply if the present drought continues to worsen through, say, 2005 or 2006. If the statement does not apply, please don't check it.

Is The *DISTRICT* Vulnerable To Or Might It Become Vulnerable To:	Current (2003) Situation	Drought Deepens Into 2005 Or 2006
Single water source	☐	☐
Low water supply reliability	☐	☐
Lack of or inadequate water storage	☐	☐
Low priority water/contractual rights	☐	☐
Imported water supply	☐	☐
High growth area/high additional demand (urban growth affecting irrigation supply)	☐	☐
Sudden change in water supply	☐	☐
Water supply at risk from contamination	☐	☐
Severe water supply shortage	☐	☐
Water supply is subject to other natural disasters	☐	☐
Threat ignored; action not taken until water supply shortage became real	☐	☐
Lack of drought planning/preparedness	☐	☐
Lack of collaboration or coordination with others in planning or preparing for drought	☐	☐
Lack of data/single source data for drought forecasting and planning	☐	☐
No political will to act	☐	☐
Wide precipitation variation	☐	☐
Uncertain/low priority power supply	☐	☐
Non-interconnected water supply	☐	☐

Are there any other circumstances that make you vulnerable to the drought? What circumstances?

Chapter III Annex

Dairies And Feed Yards

By

Bas Aja, Executive Vice President
Arizona Cattle Feeder's Association

Dairies and Feed Yards

by

Bas Aja, Executive Director
Arizona Cattlemen's Association

Arizona's Dairies and Feed Yards (CAFOS) concentrate animals in production facilities to provide for economic efficiency in the production their finished products – milk and beef. These types of facilities are reliant upon crop producers for the production of the primary inputs for formulating animal feeds – feed grains and forage.

In Arizona the main supply of forage comes from irrigated agriculture in the form of alfalfa hay. This forage product is raised across Arizona but the primary areas of production are in Cochise, Yuma, Pinal and Maricopa Counties. These facilities have a wider variety of options in determining a source of feed grains. Arizona as a state is a net importer of feed grains for animal production. While feed grains are primarily grown in Cochise, Yuma, Pinal and Maricopa Counties, these facilities will purchase feed grains from as far away as Illinois. The grain is then shipped into Arizona via the railroad and delivered to these facilities.

These types of facilities have differing needs levels as it relates to water required for production. For instance, dairies utilize much more water in the daily washing animals for food safety reasons and for the use of cooling the animals during the summer. This cooling is required to keep milk production at sufficient levels during the hot summer months. Feed yards do not wash animals nor do their animals require cooling for production. However, both of these facilities require water for the hydration of the animals and in the processing of feed grains (steam flaking).

These facilities have to comply with a number of regulations that impact their use of water. In Arizona's Active Management Areas Dairies have a conservation limit of 120 gallons of water per head/per day and feed yards have a conservation limit of 20 gallons per head/per day. In addition to these water conservation requirements they must abide by Particulate Matter (Dust) regulations. These regulations require them to utilize water in their production areas for dust suppression. There are times when all of the required and regulatory uses push the limits of the conservation requirements.

Drought is no stranger to Arizona's Dairies and Feed Yards. Arizona is a state of diverse topography representing seven different climatic regions. The State's overall average annual rainfall is eleven inches. However, in the parts of the state that are home to the dairies and feed yards the average annual rainfall ranges from 9 inches in the south central region to 3 inches in the southwestern region.

The dairies and feed yards in Arizona benefit from the year-round cropping season in our state. With this year-round cropping pattern and access to irrigation, dairies and feed yards usually find sufficient enough forage supplies produced locally to meet their production needs. However, they would be susceptible to drought if irrigated agriculture were reduced. The loss of production of forage crops would be costly to these facilities.

Because of the large numbers of animals contained at these facilities, nearly all dairies and feed yards must have secondary and tertiary sources of water for their operations. If the primary source of water was lost they have contingency plans for providing water to their animals from these secondary or tertiary sources. These sources include both ground and surface water, depending on the location. An extended drought could impact how and where they find these other sources of water.

The following is a list of the profile of the counties where feed yards exist:

Maricopa County Profile

Two commercial feed yards are currently operating in Maricopa County. According to the Arizona Agricultural Statistics Service these feed yards marketed a total of 20,000 head in 2002. Both of these feed yards have a one-time capacity of less than 10,000 head. Maricopa County encompasses 5,834,000 total acres. In 2002, there were 291,770 acres in crop production in the County. The average annual rainfall is 7.5 inches.

Pinal County Profile

Five commercial feed yards are operating in Pinal County. During 2002 these feed yards marketed a total of 274,000 head. Three of the feed yards have a one time capacity of less than 30,000 head, one has a one time capacity of less than 35,000 head and one has a one time capacity of less than 105,000 head. Pinal County encompasses 3,420,000 total acres. In 2002, there were 212,305 acres in crop production. The average annual rainfall is 9.25 inches.

Yuma County Profile

One commercial feed yard is operating in Yuma County. During 2002 this feed yard marketed approximately 130,000 head. The feed yard has a one-time capacity of under 105,000 head. Yuma County encompasses 3,526,000 total acres. In 1997, there were 228,165 acres in crop production. The average annual rainfall is 3.17 inches.

Table of County Profiles

County	# Feedyard	Avg. Rain-fall	Total acres	Total crop acres	# head cattle marketed
Maricopa	2	7.66	5,834,000	291,770	20,000
Pinal	5	9.25	3,420,000	212,305	274,000
Yuma	1	3.17	3,526,000	228,165	130,000

Chapter III Annex

All Comments Made By Survey Respondents
(Organized by Survey Section)

Comments from Survey Section I: Statistical Information

From SRP – on acre feet delivered in 2000 & 2001:
Delivery amounts should be considered estimates. Actual delivery amounts can be found in SRP's annual ADWR water use reports.

From SRP – on 'normal' sources of water:
CAP is not a "Normal Source" for SRP and is being used because of the drought.

From YCWUA – on 'normal' water deliveries:
Plus deliveries to Mexico via Boundary Pumping Plant (SIB) = 103933 (2000) & 111263 (2001).

From McMullen Valley IDD – on 'normal' water deliveries:
This district does not deliver irrigation water.

Comments from Survey Section II: Vulnerability To Long-Term Drought

From New State IDD – on vulnerability in general:
SRP, under contractual obligations, supplies water to new state. Water allocation is exactly the same as SRP's shareholders. There is a slim chance that the contract with SRP could be vulnerable to severe drought conditions.

From New Magma IDD – on vulnerability in general:
Many of the statements in this section, would effect New Magma's ability to remain a viable district. As demand for CAP water has increased, system capacity and their ability to deliver water at the needed time to Districts has decreased. If present drought and current growth patterns continue, capacity could become a real obstacle.

From San Carlos IDD – on vulnerability in general:
Our water supply from Gila River is highly variable. We have adequate storage capacity but no water to store. Wells are located to where half the district cannot use them. Canals are not lined. CAP water cost are prohibitive

From Yuma County Water Users Association – on vulnerability in general:
As senior entitlement holders, on the Colorado River, we are last to be affected, but a source and target for more junior water rights holders.

From SRP – on acre feet delivered in 2000 & 2001:
Delivery amounts should be considered estimates. Actual delivery amounts can be found in SRP's annual ADWR water use reports.

From Yuma County Water Users Association – on vulnerability factor, "Lack of or Inadequate Storage: Regulatory Storage in Yuma Area.

IV. IMPACTS

Introduction

The statewide survey of irrigation district managers listed seventeen drought impact statements (see Survey Section Annex to Chapter III). Irrigation district managers were asked to describe their opinion about how the current drought might impact conditions in the district. Considering each statement, was the drought likely to cause minor or no impact, some impact, or significant impact? As in other survey sections, district managers were also invited to make open-ended comments. All twenty-two district managers responded to at least one statement. Together, the responding irrigation districts are located throughout Yuma, La Paz, Maricopa, Pinal, and Pima Counties. They delivered about 2.18 million acre-feet of water to irrigated agriculture in each of the baseline years of 2000 and 2001. All data from survey Section III is shown on Table 5 – Drought Impacts: District Manager Views. A Chapter III Appendix reports all comments made by the 22 responding managers.

The Work Group has divided the 17 impact statements into four categories:
- ✓ Financial viability, income loss, and land prices
- ✓ Agronomic impacts: Planted acres, crop quality, land productivity, pest infestation, and yield declines
- ✓ Supply depletion and other environmental concerns
- ✓ Other impacts

Discussion of individual statements in the remainder of this chapter is organized by these categories and supported by tables that summarize statement-by-statement responses. All information on the summary tables was extracted from Table 5 . It is often illustrative to relate these statements to geographic location, type and number of water supply sources, priority, and vulnerability circumstances, that is, the data in Chapter II. The next section summarizes this Chapter.

Summary of Results:
Long-Term Drought Impacts, with Some Concluding Notes on the Relation Between Impacts and Drought Vulnerabilities

Water Supply Depletion

If water supplies in responding districts do not improve over the next year or two, the responding managers expect impact from ground water depletion, water table declines, and reservoir and lake drawdown (Chapter III Summary Table). On the survey, related impact statements respectively received the highest and fifth-highest (tie) total scores among the seventeen impacts listed on the survey. Impacts from ground water depletion and water table declines are expected throughout Maricopa, Pinal, and Pima Counties. Supply sources in concerned districts include ground water, surface water from principal Arizona streams, and CAP. Several districts concerned about depletion rely on several sources of supply. In terms of priorities, only Colorado mainstem users with senior rights were unconcerned about ground water depletion and water table declines (four such responding districts do not deliver ground water). Looking at reservoir and lake drawdown, seven districts expecting significant impact over the next year or two represent all surveyed areas, all priority classes, and all water sources. Again, districts that rely on several water sources were concerned about reservoir and lake drawdown.

Energy demand and supply

By the summer of 2004, drought had already impacted energy demand and supply in several responding districts. If water supplies do not improve over the next year or two, the responding managers expect intensified drought-induced impacts on energy demand and supply. This statement received the second-highest score (tie) among the seventeen impacts listed on the survey. A number of central Arizona districts relying on a combination of ground water (whether supplied by the district or from individually-owned wells) and either Junior CAP or other Arizona surface supplies indicated "significant impact". Increasing demand for and reduced supplies of power can combine to raise unit power costs and increase total power expenditures, whether at district or individual grower level. The pronounced move to ground water has increased energy demand and raised power expenditures among well-operators, both individual and district. Power is supplied to many irrigators under fixed-price, long-term contracts. As these expire and are renogitated in the current environment, those prices will rise.

Income loss and financial viability

If water supplies in responding districts do not improve over the next year or two, the responding managers expect income losses to both farmers and the district and adverse impacts on the financial viability of irrigation districts. On the survey, impact statements related to income loss and district financial viability respectively received the second-highest (tie) and fifth-highest (tie) total scores. Secondary economic impacts – ripple effects – in the form of economic loss to secondary business and commerce dependant on

Table 4: Summary of Results – Long-Term Drought Impacts

QUESTION

"Below are several statements reguarding the possible impacts across the *DISTRICT* of the current drought. Please circle the number that best describes your opinion about how the current drought might impact conditions in the *DISTRICT*, assuming water supply does not improve over the next year or two. Considering the statement, is the drought likely to cause:

1 = Minor or no impact;
2 = Some impact;
3 = Significant impact."

SUMMARY OF RESULTS

Top and Bottom Five Statements, Ranked by Total Score

Top Five Statements *(by total score)*	Total Score	No. '3's	Bottom Five Statements *(by total score)*	Total Score	No. '1's
Increased GW depletion/w. table decline	47	11	Air quality effects/PM-10 problems	24	15
Increased energy demand/reduced supply	41	7	Insect, disease, pest infestation	27	13
Income loss – farmers and the District	41	7	Decreased land prices in the District	27	14
Fewer planted acres in the District	38	6	Cost of water transportation	29	11
Financial viability of the District	37	5	Water quality effects	32	10
Reservoir and lake drawdown	37	7			

All twenty-two managers responded to at least one of seventeen statements. Derivation of the Total Score is explained in following text.

primary agricultural production were also a concern to several managers. To the degree that reduced water supplies translate into idled cropland, yield or quality declines, increased pest problems, increased costs, and the like, on-farm income is likely to be lost. These same effects can impact the financial viability of irrigation districts, because delivery volumes often translate into a principal revenue stream of many districts – e.g., per acre-foot water charges. When delivered supplies fall, district revenues also fall. This has led some districts to increase per acre assessments, which translates back to decreased on-farm income. Employment at districts, on-farms, and in other agriculturally dependant commerce can be negatively impacted in these circumstances.

Planted acres

If water supplies in responding districts do not improve over the next year or two, the surveyed managers expect impact from fewer planted acres, in other words, drought will cause the number of acres in production to decline. On the survey, the associated impact statement received the fourth-highest total score. Seven districts indicating "significant impact" are in Maricopa and Pinal Counties, all seven rely on ground water plus either Junior CAP or surface supplies from other principal Arizona streams. Anecdotal information provided by three managers indicates that, in fact in 2003, drought idled thousands of acres in at those three districts, an impact that can be expected to worsen and spread to other districts if the drought persists into 2004 and 2005 (See Doug Mason Chapter Annex). This land idling was caused by drought-induced reduced stream flow, combined with junior claims that could not be compensated from other sources, such as wells.

Concluding Notes on the Relation Between Long-Term Drought Vulnerabilities and Impacts

In general, it appears that managers from those districts relying on a combination of ground water from either district or individual grower wells plus Junior CAP supplies (including in-lieu) were **more likely to indicate 'significant impacts'** on the survey (Table 5).

It can be seen that several of the leading trends discerned in Chapter II are about to translate into, and in some areas have already translated into, **income loss for farmers and districts** and adverse impacts on the **financial viability of districts**. Fewer planted acres is one source of income loss and decreased financial viability. From Chapter II, related trends worthy of note include severe supply shortages, sudden supply changes, low water supply reliability, and uncertain or low priority power supplies.

Concerns about **supply depletion** appear to reinforce Chapter II discussion about a seriously worsening supply situation if the drought continues to deepen for even two or three more years. The impacts associated with reservoir and lake drawdown translate into an increased reliance on and use of ground water, which associate in-turn with increased ground water depletion and water table declines. In terms of Chapter II vulnerabilities, **supply depletion** impacts can be associated with lack of and inadequate storage, wide precipitation variation on watersheds, and low water supply reliability. In term of Chapter II trends, it seems clear that drought and other recent supply effects are impacting ground water supplies in Arizona. **Supply depletion** may translate into higher production costs and fewer planted acres.

Concern over impacts from **increased power demand and reduced supply** (assuming the supply situation does not improve over the next year or two) similarly appear to exacerbate two vulnerability trends noted in Chapter II. One trend is the increasing drought-induced reliance on ground water, which may cause static water tables to fall and lifts to increase. The second trend is drought-induced exposure to uncertain or low priority power supplies. A net effect was noted, that power demand and unit costs both may rise at the same time as power supply may be diminishing. This increases total power expenditures, whether at district or individual grower level, in-turn increasing district and grower financial vulnerability.

In 2003, **fewer planted acres** in three affected districts were associated with Chapter II vulnerabilities related to uncertain or unreliable supplies, wide precipitation variation on watersheds, dependence on single sources, and inadequate storage.

Drought Impacts on Arizona's Dairies and Feed Yards

An extended drought could impact how and where Arizona's dairies and feed yards find and produce their water supplies (Chapter II Annex, "Dairies and Feed Yards"). Any interruption of production due to declining or intermittent water supplies will be associated with severe economic impacts to Arizona's dairies and feed yards. This includes the production of grain and forage that supply the livestock feeding industry, as well as impacts on animals being fed. Any decline in feed quality caused by water shortage will have similar negative economic impacts. Any drought-induced lengthening of the feed supply chain (reliance on more distant feed) also implies increased cost to the industry.

Survey Results – Drought Impacts

This section presents detailed survey results on drought impacts, with the seventeen individual impact statements from the survey grouped into four classes. All data in following sub-sections is based on Tables 5.

Financial Viability, Income Loss, and Land Prices

Our statewide survey of irrigation district managers listed three statements relating to impacts on financial viability, income, and land prices (see Chapter Annex – Survey Section III):

- ✓ Financial viability of the irrigation District;
- ✓ Income loss for farmers and the District;
- ✓ Decreased land prices in the District

Either nineteen or twenty district managers responded to each item. The table below summarizes their responses.

Impacts: Financial Viability, Income Loss, and Land Prices

	How Many Managers Said:			
Impact Statement *(number responding)*	Minor Impact *(1 point)*	Some Impact *(2 points)*	Significant Impact *(3 points)*	Total Score
- Income loss for farmers & district (*n=20)*	6	7	7	41
- Financial viability of the district *(n=20)*	8	7	5	37
- Decreased land prices in the district *(n=19)*	14	2	3	27

This table shows the number of managers who responded to each level of the statement. Then, a total score for the statement is arrived at by counting a response of "minor or no impact" as one, "some impact" as two, and "significant impact" as three. For example, 20 managers responded to the statement, "Income loss for farmers and the District". Of the 20, six said "minor or no impact," seven "some impact', and seven "significant impact." For this statement, a total score was then derived as follows:

$$41 = (6 \times 1) + (7 \times 2) + (7 \times 3)$$

If water supplies in responding districts do not improve over the next year or two, the surveyed managers expect income losses to both farmers and the district. This statement received the second-highest score (tie) among the seventeen impacts listed on the survey. Five of the six responses of "minor or no impact" came from the Yuma-area (Table 5). All seven responses of "significant impact" came from Maricopa and Pinal County. These districts (and individual growers within the districts) rely on either groundwater (for at least 80% of supplies), or a combination of ground water and one other source. To the degree that reduced water supplies translate into idled cropland, yield or quality declines, increased pest problems, increased costs, and the like, income is likely to be lost.

Responding managers also expect adverse impacts on the financial viability of irrigation districts, if water supplies do not improve over the next year or two. This statement tied for fifth-highest score. Again, responses of "minor or no impact" were concentrated in Yuma County (five of eight), while all seven responses of "significant impact" came from Maricopa and Pinal County districts where groundwater or a combination of ground water with one other source constitute district supplies. Delivery volumes translate into a principal revenue stream of many districts – e.g., per acre-foot water charges – so that when delivered supplies fall, so do district revenues. A survey quote from a responding district manager illustrates this point:

> "Any impact an irrigation district sustains due to the current drought and/or future should be considered detrimental to the sustained financial viability of both the district and its customers." (See Chapter III Annex –

All Comments Made By Survey Respondents – Organized by Survey Section).

The prospect of falling land prices was a minor concern for most responding managers. Fourteen of nineteen said “minor or no impact”. Again quoting a responding manager:

> “Land within the district is being sold to developers at a faster rate than previously.”

It can be seen that several of the leading vulnerabilities and trends discerned in Chapter II are about to translate into, and in some areas have already translated into, income loss for farmers and districts and adverse impacts on the financial viability of districts. From Chapter II, vulnerabilities and trends worthy of note include reliance on single water sources, lack of or inadequate storage, low priority rights (of note in Central Arizona districts in 2003), low water supply reliability, and the trends associated with severe shortages and sudden supply changes.

Agronomic Impacts:Planted Acres, Crop Quality, Land Productivity, Pests, and Yields

The statewide survey of irrigation district managers listed five statements relating to agronomic impacts: Planted acres; crop quality; land productivity; insect, disease, or pest infestation; and yield declines (see Chapter Annex – Survey Section III):

- ✓ Fewer planted acres in the District
- ✓ Damage to crop quality in the District
- ✓ Reduced productivity of cropland in the District
- ✓ Insect, disease, or pest infestation in the District
- ✓ Yield declines in the District

Either nineteen or twenty district managers responded to each item. The table below summarizes their responses.

Agronomic Impacts: Planted Acres, Crop Quality, Land Productivity, Pests, and Yields

	How Many Managers Said:			
Impact Statement *(number responding)*	Minor Impact *(1 point)*	Some Impact *(2 points)*	Significant Impact *(3 points)*	Total Score
- Fewer planted acres in the district *(n=20)*	8	6	6	38
- Damage to crop quality in the district *(n=20)*	10	8	2	34
- Reduced cropland productivity *(n=19)*	10	3	6	34
- Yield declines in the district *(n=20)*	10	7	3	33
- Insect, disease, pest infestation *(n=19)*	13	4	2	27

This table shows the number of managers who responded to each level of the statement. Then, a total score for the statement is arrived at by counting a response of “minor or no impact" as one, "some impact" as two, and "significant impact" as three. For example, 20 managers responded to the statement, "Fewer planted acres in the District". Of the 20, eight said "minor or no impact," six "some impact', and six "significant impact." For this statement, a total score was then derived as follows:

$$38 = (8 \times 1) + (6 \times 2) + (6 \times 3)$$

If water supplies in responding districts do not improve over the next year or two, the surveyed managers expect impact from fewer planted acres, in other words, drought will cause the number of acres in production to decline. This statement received the fourth-highest score among seventeen impacts listed on the survey. Three of four Yuma County districts with senior Colorado River rights but only one small district relying on a principal Arizona stream other than the Colorado were among the eight indicating a response of "minor or no impact" to this statement. Five of six districts responding "significant impact" rely on a combination of ground water plus CAP and other (not mainstem Colorado) surface water. Anecdotal information provided by three managers indicates that, in fact in 2003, thousands of acres were idled in at least three districts, an impact that can be expected to worsen and spread to other districts if the drought persists into 2004 and 2005 (See Doug Mason Chapter Annex). In 2003, impacts from fewer planted acres were associated with Chapter II vulnerabilities related to uncertain or unreliable supplies, wide precipitation variation on watersheds, dependence on single sources, and inadequate storage.

Concerns about drought impacts on crop quality, reduced cropland productivity, and yield declines ranked in the middle of the seventeen statements, while drought-induced pest problems ranked in the bottom five among the seventeen statements on the survey.

Supply Depletion and Other Environmental Concerns

The statewide survey of irrigation district managers listed four statements categorized as resource or environmental concerns. Two relate to the depletion of water resources and two relate to water and air quality (see Chapter Annex – Survey Section III):

- ✓ Increased ground water depletion/water table decline
- ✓ Reservoir and lake drawdown
- ✓ Air quality effects/PM-10 problems in the district
- ✓ Water quality effects (salt concentration, increased water temp., etc.)

Either nineteen, twenty, or twenty-one district managers responded to each item. The table below summarizes their responses.

Impacts: Supply Depletion and Other Environmental Concerns

	How Many Managers Said:			
Impact Statement *(number responding)*	Minor Impact *(1 point)*	Some Impact *(2 points)*	Significant Impact *(3 points)*	Total Score

- GW depletion / water table decline *(n=21)*	6	4	11	47
- Reservoir and lake drawdown *(n=19)*	8	4	7	37
- Water quality effects *(n=20)*	10	8	2	32
- Air quality effects / PM–10 problems *(n=19)*	15	3	1	24

This table shows the number of managers who responded to each level of the statement. Then, a total score for the statement is arrived at by counting a response of "minor or no impact" as one, "some impact" as two, and "significant impact" as three. For example, 21 managers responded to the statement, "Increased ground water depletion/water table decline". Of the 21, six said "minor or no impact," four "some impact', and eleven "significant impact." For this statement, a total score was then derived as follows:

$$47 = (6 \times 1) + (4 \times 2) + (11 \times 3)$$

If water supplies in responding districts do not improve over the next year or two, the responding managers expect impact from ground water depletion and water table declines. This statement received the highest score – 47 – and the most responses of "significant impact" – 11 – among the seventeen impacts listed on the survey. The impact cut across Maricopa, Pima, and Pinal Counties. By contrast, responses of "minor or no impact" were concentrated in the Yuma-area (Table 5), and four of the six districts making this response do not deliver ground water. Looking further, water sources include ground water, surface water from principal Arizona streams, and CAP. All priorities are also represented in this group, except Colorado mainstem users with senior rights. Several districts anticipating impacts from ground water depletion rely on several sources of supply. Readers are referred to the Chapter II trends discussions relating to the increased use of ground water: It seems clear that drought and related supply effects are impacting Arizona ground water supplies.

The statement relating to reservoir and lake drawdown received the fifth-highest score (tie) among the seventeen impact statements. Looking at the eight responses of "minor or no impact," none came from a district relying on principal Arizona streams (other than the Colorado). Conversely, the seven making the "significant impact" response represent all surveyed areas, all priority classes (including one senior mainstem Colorado user), and all water sources. Again, districts that rely on several water sources are represented. (e.g., wells plus surface water supplies).

Adverse air and water quality effects were minor concerns for most responding managers, ranking in the bottom five among the seventeen statements on the survey.

The concerns about supply depletion discussed here reinforce the trends discussion in Chapter II, to the effect that a number of managers anticipate a seriously worsening supply situation if the drought continues to deepen for even two or three more years.

Other Long-Term Drought Impacts

The statewide survey of irrigation district managers listed five statements categorized as other long-term drought impacts (see Chapter Annex – Survey Section III):

- ✓ Increased energy demand and reduced supply due to drought-related power curtailments
- ✓ Economic loss to secondary business/commerce directly dependant on primary agricultural production (gins, dealers, suppliers, etc.)
- ✓ Lost production contracts (dairies, vegetables, processors, etc.)
- ✓ Cost of water transportation (wheeling)
- ✓ Cost of new or supplemental water resource development at District level

Either nineteen, twenty, or twenty-two district managers responded to each item. The table below summarizes their responses.

Other Long-Term Drought Impacts

	How Many Managers Said:			
Impact Statement *(number responding)*	Minor Impact *(1 point)*	Some Impact *(2 points)*	Significant Impact *(3 points)*	Total Score
- Increased energy D & reduced S *(n=22)*	10	5	7	41
- Cost of water resource development *(n=19)*	10	3	6	34
- Lost production contracts *(n=20)*	11	5	4	33
- Secondary economic impacts *(n=19)*	9	6	4	33
- Cost of water wheeling *(n=19)*	11	6	2	29

This table shows the number of managers who responded to each level of the statement. Then, a total score for the statement is arrived at by counting a response of "minor or no impact" as one, "some impact" as two, and "significant impact" as three. For example, all 22 managers responded to the statement, "Increased energy demand and reduced supply due to drought-related power curtailments". Of the 21, ten said "minor or no impact," five "some impact', and seven "significant impact." For this statement, a total score was then derived as follows:

$$41 = (10 \times 1) + (5 \times 2) + (7 \times 3)$$

If water supplies in responding districts do not improve over the next year or two, the responding managers expect drought-induced impacts on energy demand and supply. This statement received the second-highest score (tie) among the seventeen impacts listed on the survey. Looking at the geographic distribution and supply sources of the seven districts responding "significant impact" (Table 5), all seven are in Maricopa and Pinal Counties. Five rely on ground water and Junior CAP supplies (including both the district and individual growers within it), and two more rely on ground water and supplies from other principal Arizona streams. Of the ten district managers who responded "minor or no impact", four are in the Yuma area and do not deliver ground water, two are very small, and one does not deliver water. Two Chapter II trends are noteworthy in light of district manager concerns over adverse energy demand and supply impacts. One trend is the increasing drought-induced reliance on ground water. The second trend is drought-induced vulnerability to uncertain or low priority power supplies. A net effect was noted in Chapter II, that power demand and unit costs both may rise at the same time as power supply may be diminishing. This increases total power expenditures, whether at district oı individual grower level, in-turn increasing district and grower financial vulnerability.

With total scores of either 34 or 33, impact statements about the cost of new or supplemental water resource development at District level, lost production contracts, and economic loss to secondary business and commerce directly dependent on primary agricultural production ranked in the middle one-third of the seventeen statements. Nevertheless, one of the responding managers did say,

> "I was very happy to see in this section, the inclusion of surrounding industries that depend on agriculture."

Expected impacts from the cost of water wheeling had a total score (29) among the four lowest statements on the survey.

Eastern and South Eastern Arizona

Informants in the Upper Gila – Safford Valley area report that declining ground water tables have caused shallower wells to surge and well yields to decline, while surface water allocations from the Gila River have been at or near zero for several years. Planted acres have been cut back. The GVID survey notes significant negative impacts in all of our summary categories. Water supplies are depleting. Energy demand is increasing while supplies are declining or being curtailed. There has been income loss for farmers and the ditch companies, as well as economic loss to secondary business and commerce directly dependent on primary agricultural production.

Overdraft and declining water tables have been a chief concern in the Sulphur Springs Valley since before the 1970's. Under conditions of long-term drought, access to water becomes the principal limiting factor for agriculture in the region. Access is largely determined by the depth from which water has to be pumped and the costs of pumping it. Meanwhile, the SSV is subject to the same drought impacts on power demand and supply experienced elsewhere in Arizona and the southwest. So, drought in the SSV tends to increase the depth to water and pumping costs. These associate with increased water supply uncertainty and increased costs to farm. During the 1970's, declining water tables caused a large percentage of farms in the SSV to go out of business.

TABLE 5. DROUGHT IMPACTS: DISTRICT MANAGER VIEWS

IRRIGATION DISTR	COU	AF (00+01)/2	FINANCE and INCOME: Income	Finance	Land prices	AGRONOMIC IMPACTS: Planted acres	Crop quality	Produc-tivity	Yield	Pests	SUPPLY DEPLETION / ENVIRONMENT: Ground water	Reser-voir	W. Q.	Air Q	OTHER IMPACTS: Energy	Cost to develop	Lost contracts	Second. economic	Wheeling
Central Arizona Ir	Pina	227214	2	2	3	2	2		2	1	2	1	1	1	3	2	2	2	1
Cortaro-Marana Ir	Pima	33500									3				1				
Harquahala Valley	Mari	97182	3	2	1	3	2	3	2	2	3	1	1	1	2	2	3		2
Hilander "C" Irriga	Yum	0	1	1	1	1	1	1	1	1	2	1	2	1	2	1	1	1	2
Hohokam Irrigatio	Pina	74525	3	2	3	2	1	1	1	2	3	3	2	1	3	1	2	3	2
Hyder Valley Irrig	Mari	4	3	3	1	3	3	3	3	1	3	1	1	1	1	1	1	1	1
Maricopa-Stanfiel	Pina	236350	1	1	1	1	1	1	1	1	2	1	1	1	2	2	1	2	1
Maricopa Water D	Mari	57700	3	3	1	3	3	3	3	3	3	3	3	2	3	3	2	2	3
McMullen Valley Ir	LaPa	0													1				
New Magma Irriga	M-P	91799	3	3	2	3	2	3	1	1	3	3	2	1	2	3	3	3	2
New State Irrigati	Mari	717	2	2	1	1	2	2	2	2	2	2	2	1	1	1	2	2	1
Roosevelt Water C	Mari	98440	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Roosevelt Irrigatio	Mari	167898	2	2		2	2	2	2	2	3	3	2	2	3	3	2	2	
Salt River Project	Mari	149597	2	1	1	2	1	1	2	1	1	2	1	1	1	1	1	1	1
San Carlos Irrigat	Pina	56343	3	3	1	3	2	3	1	1	3	3	2	2	3	3	3	3	2
San Tan Irrigation	Mari	3222	2	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1
Tonopah Irrigation	Mari	14785	2	2	2	1	1	1	1		3		1		3		1	1	1
Unit "B" Irrigation	Yum	27612	1	1	1	1	1	1	1	1	1	3	2	1	1	1	1	1	1
Wellton-Mohawk I	Yum	400000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Yuma Irrigation D	Yum	61069	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1
Yuma County Wat	Yum	244108	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Paloma Irrigation	Mari	137545	2	2	1	2	2	2	2	1	3	2	2	1	2	3	1	2	2
Total Score			41	37	27	38	34	34	33	27	47	37	32	24	41	34	33	33	29
Rank (by highest total score)			T-2	T-5		4					1	T-5			T-2				
Number responding			20	20	19	20	20	19	20	19	21	19	20	19	22	19	20	19	19

Chapter IV Annex

Irrigated Agriculture Survey Section III:

Impact of Drought

III. IMPACT OF DROUGHT

Below are several statements regarding the possible impacts across the *DISTRICT* of the current drought. Please circle the number that best describes your opinion about how the current drought might impact conditions in the *DISTRICT*, assuming water supply does not improve over the next year or two: Considering the statement, is drought likely to cause minor or no impact, some impact, or significant impact across the *DISTRICT*?

Minor or no impact = 1 Some impact = 2 Significant impact = 3

Possible Drought Impact	**How Much Impact?**		
Financial viability of the irrigation District	1	2	3
Income loss for farmers and the District	1	2	3
Fewer planted acres in the District	1	2	3
Damage to crop quality in the District	1	2	3
Reduced productivity of cropland in the District	1	2	3
Insect, disease, or pest infestation in the District	1	2	3
Increased energy demand and reduced supply due to drought-related power curtailments	1	2	3
Economic loss to secondary business/commerce directly dependant on primary agricultural production (gins, dealers, suppliers, etc.)	1	2	3
Yield declines in the district	1	2	3
Lost production contracts (dairies, vegetables, processors, etc.)	1	2	3
Cost of water transportation (wheeling)	1	2	3
Cost of new or supplemental water resource development at District level	1	2	3
Decreased land prices in the District	1	2	3
Increased ground water depletion/water table decline	1	2	3
Reservoir and lake drawdown	1	2	3
Air quality effects/PM-10 problems in the District	1	2	3
Water quality effects (salt concentration, increased water temp, etc.)	1	2	3

Besides these possible drought impacts, are there any other impacts on the *DISTRICT* from the current drought?

Chapter IV Annex

All Comments Made By Survey Respondents
(Organized by Survey Section)

Comments from Survey Section III: Impact of Drought

From San Carlos IDD:
Land within the district is being sold to developers at a faster rate than previously. Developers do not care about the water supply.

From New Magma IDD :
I was very happy to see this section, the inclusion of surrounding industries that depend on agriculture.

From YCWUA :
As senior water entitlement holders it should be a minor impact. In the event that significant fallowing occurs to make water available for others, then the highlighted items have an impact.

From Roosevelt WCD:
Any impact an irrigation district sustains due to the current drought and/or future should be considered detrimental to the sustained financial viability of both the district and its customers.

Chapter IV Annex

Impact of the Drought on the San Carlos Irrigation District

By

Douglas Mason
General Manager – San Carlos Irrigation and Drainage District

Impact of the Drought on the San Carlos Irrigation District
By Douglas Mason
January 21,2003

Hello, My name is Douglas Mason. I am the General Manager for the San Carlos Irrigation and Drainage District. Before I get into how the drought has impacted the District I would first like to give you some information about the District. The Bureau of Indian Affairs authorized by the San Carlos Irrigation Project Act of 1924 built the District canal system. The San Carlos Irrigation Project (Project) was authorized to irrigate a total of 100,000 acres in Pinal County with 50,000 acre on the Gila River Indian Reservation and 50,000 acres of non-Indian District farms. The District was created to operate and maintain the non-Indian portion of the Project. The lands the District serves stretch from the towns of Florence, Coolidge to the city of Casa Grande. The District delivery system consists of 205 miles of unlined earth canals. The District water supply comes from three sources; Gila River surface water, ground water and CAP water.

The main portion of the Project water supply is from surface water. The surface water supply for the Project is from the upper Gila River with storage behind Coolidge Dam. The contributing drainage to the Project is from southwestern New Mexico, southeastern Arizona and Mexico. The total contributing drainage area above Coolidge Dam is 12,800 square miles. There are 4,680 square miles in the San Pedro River drainage area below Coolidge Dam and above Ashurst Hayden for the total drainage area of 18,500 square miles. The drainage basin elevation ranges from 10,000 feet in the mountains to 1600 feet at Ashurst-Hayden Diversion Dam. The water from Coolidge Dam is released down the Gila River and is diverted from the Gila River 65 miles downstream at Ashurst-Hayden Diversion Dam.

The runoff from the Gila drainage basin is highly variable. From 1936 to present the inflow to Coolidge Dam has ranged from a low of 19,000 ac-ft in 1956 to a high of 1,900,000 ac-ft in 1993. The average inflow is 338,000ac-ft. Do you know what a good example of average is? If you put your head in the freezer and your feet in the oven on the average you are comfortable. The driest years the District has ever experienced over the last 67 years of its history was during the 1950's. The last five years has come close to tying this period of record.

In addition to the surface water the Project has a total of 100 wells that deliver water to the Project. 50 of the Project wells supply groundwater to the District's portion of the Project. The pumping capacity of the Project wells is limited and can only supply a small portion of the total Project water supply needs. During periods of normal runoff the pumped water supply is about 5-10 % of our water supply. **Last year the pumped water delivered was 95% of the apportioned water delivered.** In addition to the Project water supplies some of the District farmers have purchased 7,000 ac-ft/year of CAP water over the last couple of years.

The drought over the last 5 years caused several compounding problems. The most obvious problem is that with reduced amount of surface water available to the Project and a limited amount of ground water pumping, the amount of water that can be delivered to the District farm is reduced. This reduced surface water supply causes further problems. With reduced river flows below Coolidge Dam the percentage of river losses increase. When the river flows are 600cfs or better the river losses are 7-12%, when the flows are reduce to 100cfs to 200 cfs the percentage of river losses can run as high as 35%. The canal losses increase in the canals as well with reduced flows and the canals being alternating wet and dry because of reduced irrigation demands. The increase river and canal losses mean even less of the available stored water makes it to the farm.

Of course when the surface water supplies are reduced the Project pumping is maximized to the extent possible. But the Project wells that deliver water to the District during periods of drought are mainly located in the Florence and Coolidge area. Without some surface water available the area around Casa Grande cannot be supplied with Project water. This had not been a problem until the 2003 irrigation year when we started the year with a total of 5,900 ac-ft of stored water at Coolidge Dam. The Project water deliveries were cut off to the Casa Grande area at the end of May. There were some runs of CAP water in the Casa Grande area to finish up some crops during the months of June and July.

Competition for water occurs during drought periods in areas where no competition normally exists. For instance Coolidge Dam under the original authorization was for irrigation and power generation only. Of course when space is available the reservoir can store floods and give flood protection downstream but receives no credit for flood protection. With water in storage you can create a fishery in a reservoir where recreation was not authorized. But when you drain a reservoir for irrigation purposes the fish have no place to go. In the past the reservoir was completely drained to supply water for the Project several times since 1936 eliminating the fishery. Since 1990 the Federal government and the San Carlos Apaches have used CAP water to exchange for water stored at Coolidge Dam to maintain a temporary fish pool at the reservoir. These exchanges have worked well for both Project irrigation and for maintaining the fisheries at Coolidge Dam. But this has created other problems. Before when the Reservoir was empty the gates were left open and any inflow that came into the Dam was released. It did not matter what was measured at the gauging station upstream of the Reservoir what flowed through at the gates was the release. Since the fish pool was created we have to be sure that the water being released is actually the natural flow or stored water that is in the reservoir and not part of the fish pool. It has added to the complexity of delivery and accounting for the water at Coolidge Dam.

With the reduced water apportioned or available to the Project farms the farmed acreage within the District has been reduced. The reduced apportionment and the commodity prices have also affected the crops grown within the District. There are more grains planted on District acreage than before. But at the same time the new dairies moving to Pinal County have caused more alfalfa to be grown in the District. The reduced planted acreages within the District have reduced the District farmer's income, which makes it harder to compete in a very competitive business.

This last year the apportionment dropped to .35 ac-ft/ac, which was the lowest apportionment the Project has ever had. If a farmer had water available to him he could only plant 1 acre for every 13 acres owned within the District with Project water. So far this year the National Resources Conservation Service, a federal agency who conducts snow surveys on the drainage basins is showing the upper Gila drainage basin to be at 26% of normal precipitation. Unless something changes the District is facing another year like last year. This forces the farmer and the District to look at every means to get the most out of the water available to them and to look at any method of cutting the operating cost to the minimum.

V. PREPAREDNESS AND RESPONSE

The statewide survey of irrigation district managers listed twenty-seven drought preparedness and response items (see Survey Section Annex to Chapter IV). Irrigation district managers were asked if these items were already available, would not help, might help some, or were potentially very important in drought preparedness and response. As in previous survey sections, district managers were also invited to make open-ended comments. All twenty-two district managers responded to at least one item. Together, the responding irrigation districts are located throughout Yuma, La Paz, Maricopa, Pinal, and Pima Counties, and delivered about 2.18 million acre-feet of water to irrigated agriculture in each of the baseline years of 2000 and 2001. All data from survey Section IV is shown on Table 7 - Response, Mitigation, and Adaptation Options: District Manager Views. A Chapter V Appendix reports all comments made by the 22 responding managers.

The Work Group has divided the 27 preparedness and response items into five categories:

- ✓ Forecasting and early warning
- ✓ Programs
- ✓ Agricultural water conservation
- ✓ Voluntary, market-driven water transfers
- ✓ Planning and research

The next section summarizes detailed preparedness and response information found in the remainder of this chapter. The detailed information follows, with discussion divided into the five categories, supported by tables that summarize district manager responses category-by-category. All survey response information was extracted from Table 7. Discussion in the summary and the five categories relates survey responses to the Chapter II analysis of vulnerabilities and the Chapter III analysis of impacts.

A Note on Distinguishing Between Preparedness and Response
Preparedness for long-term drought, as used by the Work Group, refers to action taken in advance of an impending drought. Such action is proactive and adaptive, designed to lessen the vulnerability to and the impact of drought, should it begin. *Response*, by contrast, as used by the Work Group, refers more to dealing with an existing or imminent drought situation, and is aimed at mitigating drought effects about to be or already being experienced.

Summary Discussion: Drought Preparedness and Response

The Work Group divided the 27 preparedness and response items into five categories. On a category basis, the breakdown between positive responses – either "might help some", or "potentially very important" – and negative responses – either "already available" or "would not help" – was:

Item Categories	Positive (%)	Negative (%)
Forecasting and early warning *(5 items)*	54	46
Programs *(4 items)*	78	22
Agricultural water conservation *(13 items)*	35	65
Voluntary, market-driven water transfers	79	21
Planning and Research *(4 items)*	58	42

Looking at the 27 items individually, the following, in order, had the highest percentage of ***positive*** responses:

Preparedness and Response Item	Positive (%)
Create drought property tax credit program for farmers	83
Guaranteed low-interest loans to drought-stricken farmers	83
Investment program: Increase flexibility of water supply sources	78
Develop a State water plan	75
Develop criteria to trigger drought-related actions	65
Improve accuracy of seasonal runoff and water supply forecasts	65

Looking at the 27 items individually, the following, in order, had the highest percentage of ***negative*** responses:

Preparedness and Response Item	Negative (%)
Five physical conservation practices[a]	76
Four management conservation practices[a]	69
Establish new data collection networks	65
Study effectiveness of water conservation measures	65

a. Most respondents said these were already available.

A Discussion of Preparedness and Response In Light of Chapter II Vulnerabilities and Chapter III Impacts

The information about preparedness and response can be summarized and interpreted in light of the analyses of vulnerability and impacts to drought from Chapters II and III. Looking first at the items dealing with **forecasting and early warning**, the mildly (54%) positive response to this category of items can be evaluated in the context of those specific Chapter II circumstances of greatest concern to district managers: Vulnerability to a single source, widely varying precipitation, low water supply reliability, sudden water supply changes, the threat of severe water supply shortage, and especially a current lack of drought planning and preparedness. One interpretation is that district managers would like to see any supply problems developing as far in advance as possible, which may reflect the Chapter II vulnerability trends discussion, namely that supply problems already existed in 2003 and may be on the verge of becoming severe if the drought were to continue for even two or three more years. In the forecasting and early warning category, developing criteria to trigger drought-related actions and improving the accuracy of seasonal runoff and water supply forecasts received the most positive responses from the district managers.

Programs received positive responses (78% positive) from 78% of our responding district managers. All individual program items included on the survey were popular. Programs can be used to respond to an existing drought or to prepare for a long-term drought eventuality. Looking at specific program items, property tax credits and low-interest loans received the highest percentage of positive responses, followed by any type of investment program that would increase the flexibility of water supply sources. Looking at the latter item and the Chapter II Summary Table, vulnerability to a single source of water was the characteristic of greatest concern to the managers.

Our statewide survey of irrigation district managers listed thirteen **agricultural water conservation** drought preparedness and response items. Overall, 65% of the responding managers said the list of thirteen items were either already available or would not help. An even higher negative response was observed to the nine physical or management conservation items listed on the survey. The Irrigated Agriculture Work Group suggests that these results should be interpreted against the backdrop of the enormous statewide conservation investments that have already been made by Arizona's irrigated agriculture at both district and on-farm levels. Conservation incentive programs have been in place over many years in most of Arizona's irrigation districts. Many district managers may see limited conservation potential in management-type approaches, perhaps reflecting a view that the performance of most growers is already high in this area. The Work Group suggests that the most promising approaches to continued agricultural water conservation might include:

- ✓ Continued participation, on a voluntary basis, in existing incentive programs directed at physical and structural conservation improvements, targeting growers who may still benefit from voluntary participation in such programs;
- ✓ Continued participation, also on a voluntary basis, in agronomic and water management outreach programs, again directed at growers who volunteer to participate;
- ✓ Continued use of tax credits, low-interest loans, crop insurance, and like programs targeted at drought preparedness, along the lines of several existing programs already popular with Arizona growers.

The idea of voluntary, willing, term-limited, and **market-driven water transfers** received responses of "might help some", or "potentially very important" from fifteen of nineteen (79%) responding district managers. Voluntary and market-driven water transfers offer one means of preparing for or responding to several of the chief vulnerability characteristics from Chapter II (Table 3), such as reliance on single supplies, a threat of severe shortages, or sudden supply changes. Great care will be required if this avenue is explored as a drought preparedness or response item. But, over a longer term, a market approach may be among the most promising drought preparedness tools. Experience elsewhere in the West shows that all parties to a successful transfer must benefit.

Forecasting, Early Warning, And Drought Preparedness And Response

The statewide survey of irrigation district managers listed five forecasting and early warning drought preparedness and response items (see Chapter Annex – Survey Section IV):

- ✓ Develop criteria to trigger drought-related actions
- ✓ Develop an early warning system
- ✓ Establish new data collection networks
- ✓ Monitor vulnerable water supplies
- ✓ Improve accuracy of seasonal runoff and water supply forecasts

Either twenty or twenty-one district managers responded to each item. The table below summarizes their responses.

Forecasting, Early Warning, And Long-Term Drought Preparedness And Response

Forecasting or Early Warning Item	A . A.	No Help	Might Help	P. I.	Totals
(5 questions, 101 total responses)	29	17	34	21	101
- Develop criteria to trigger actions *(n=20)*	6	1	8	5	20
- Develop early warning system *(n=20)*	6	2	8	4	20
- New data collection networks *(n=20)*	6	7	5	2	20
- Monitor vulnerable water supplies *(n=21)*	7	4	7	3	21
- Accurate runoff and supply forec. *(n=20)*	4	3	6	7	20

In this table, one response by one manager counts as one. For example, all 20 of the managers responded to the item, "Develop criteria to trigger drought-related actions". Of the 20, six said "Already available," one said "Would not help," eight said "Might help some," and five said "Potentially very important."

Looking at the five forecasting and early warning items together, 46 of 101, or 46%, said these were already available (29 responses) or would not help (17 responses), while 54%, or 55 of 101, said these might help or were potentially very important.

Among the individual items, triggers, accurate runoff and supply forecasts, and early warning had the highest proportion of positive responses – might help or potentially important (65%, 65% and 60% positive, respectively). New data collection networks had the highest percentage of negative responses – already available or would not help (65% negative).

The positive responses can be evaluated in the context of those specific Chapter II circumstances of greatest concern to district managers: Vulnerability to a single source, widely varying precipitation, low water supply reliability, sudden water supply changes, the threat of severe water supply shortage, and especially a (lack of) drought planning and preparedness (see the Summary Table at the end of Chapter II). We quote a comment from one of the responding district managers:

> "In my opinion, nothing can take the place of research and planning to develop an early warning system. Such a system would benefit all the water using community." (See Chapter IV Annex – All Comments Made By Survey Respondents – Organized by Survey Section).

These responses may indicate that district managers want to see a supply problem developing as far in advance as possible. They appear to reflect vulnerability trends from Chapter II, namely that supply problems already existed in 2003 and may be on the verge of becoming severe if the drought were to continue for even two or three more years. Forecasting and early warning may be more important to districts dependent on surface-water supplies, especially on watersheds where precipitation and runoff are highly variable resulting in widely fluctuating water supplies.

The negative interest in new data collection may reflect a view that much of the data needed for triggers, early warning, and accurate forecasting is probably already available, so that the issue is less new monitoring or data or even new forecasting or setting new triggers. Rather, available information may require presentation in a more readily available, easy to understand, and easy to access public location and format. An example of this approach to data collection, forecasting, early warning, and triggers can be found at the Gila River Commission website, www.gilawater.org (under development as of April, 2004). In short, benefit may come from information dissemination and raising public awareness of already-existing efforts, rather than any new initiatives in data gathering, forecasting, and early warning.

Programs And Drought Preparedness And Response

Our statewide survey of irrigation district managers listed four program drought preparedness and response items (see Chapter Annex – Survey Section IV):

- ✓ Create drought property tax credit program for farmers
- ✓ Program providing low-interest loans to drought-stricken farmers
- ✓ Investment program to increase flexibility of water supply sources
- ✓ Emergency permit program to increase flexibility of water supply sources

Eighteen district managers responded to each item. The table below summarizes their responses.

Programs And Long-Term Drought Preparedness And Response

Program Item	A . A.	No Help	Might Help	P. I.	Totals

(4 questions, 72 total responses)	0	16	36	20	72
- Property tax credit *(n=18)*	0	3	10	5	18
- Low interest loans *(n=18)*	0	3	6	9	18
- Invest-flexible water supply *(n=18)*	0	4	11	3	18
- Permits-flexible water supply *(n=18)*	0	6	9	3	18

In this table, one response by one manager counts as one. For example, 18 of the managers responded to the item, "Create drought property tax credit program for farmers". Of the 18, three said "Would not help," ten said "Might help some," and five said "Potentially very important."

Looking at the four program items together, no manager viewed any of these programs as already available, and just 16 of 72, or 22%, said would not help, while 78%, or 56 of 72, said these might help or were potentially very important. At the same time, one manager expressed the following fear:

> "Proposing to create drought property tax credit program or program providing guaranteed low-interest loans…might backfire."

The generally favorable district manager response to these ideas may indicate a positive stance toward these and perhaps other preparedness programs as a general approach to drought. Other kinds of programs may also hold promise for Arizona and show promise of grower acceptance. Reader attention is directed to the discussion of USDA – Risk Management Agency Prevented Planting (drought) Crop Insurance in the section on "Conservation", below. Several district managers emphasized the potential importance of added storage. The Work Group notes that storage need not refer only to costly large dam and impoundment projects. Storage may also refer to small scale, local, regulatory type storages, such as main canal sumps with pump-back, recharge facilities, and the like. In 2003, a conditional short-term emergency potable permit program was used in Arizona.

Programs might also be used as incentives toward comprehensive drought preparedness, or to address particular vulnerabilities and impacts. For example, eligibility for a particular program – say, for example, property tax credits or low-interest loans – could be conditioned on qualification for Arizona's new Best Management Practices conservation program for irrigated agriculture (a grower need not be required to enter this voluntary program, but qualifying to do so could be an eligibility condition under other drought programs).

Agricultural Water Conservation And Drought Preparedness And Response

Introduction

The Governor's Executive Order specifically directs the Drought Task Force to

> "Evaluate opportunities for more efficient use of water to meet agricultural and municipal needs…Agriculture (work group) shall make assessments and develop mitigation strategies including opportunities to increase water use efficiency for drought related impacts on agriculture including crops and livestock"

Without doubt, conservation is an important element in drought preparedness and response and warrants measured attention as a part of Arizona's Drought Plan. We discuss conservation and increased water use efficiency as long-term drought preparedness and response options within the context of the Irrigated Agriculture Work Group Objective which reads in part,

> "….develop response, mitigation, and adaptation strategies to sustain the long-term economic viability of Arizona's irrigated agriculture."

So, the economic viability of Arizona's agricultural growth engine is paramount as the State prepares to manage eventual long-term drought. In other words, conservation as a drought response measure is not an end in itself, but is weighed within the larger context of sustaining the economic viability of the sector over the long-term.

Arizona is a state that experiences large variations in precipitation, some areas of the state receive an abundance of precipitation and others receive very little. The general lack of available moisture in many parts of the state requires that for agriculture to be a viable enterprise crops must be irrigated. Early development of the state occurred simultaneously with the development of surface water irrigation projects. These projects caused lands to be put into production and cropped. Additional lands were added into production in the 1930s, 40s, and 50s as groundwater pump technology advanced and electricity became increasingly available.

Water for irrigated agriculture is a necessity whose cost to acquire and deliver to the field is a significant economic input into the farm budget. Because water is necessary and costly, irrigated agriculture has invested heavily in conservation measures, both on-farm and for delivery systems. These investments stretch limited supplies, increase profits, help manage situations of water supply scarcity, and help growers meet the conservation requirements of Arizona's 1980 ground water code.

Agricultural water users throughout the state have implemented physical on-farm conservation measures that include conveyance system and field irrigation system improvements. Examples of conveyance system improvements include lining ditches, piping, and installation of drain back systems. To efficiently and effectively utilize delivered water on fields, growers have invested heavily in field irrigation system improvements such as leveling, ditch lining, installing drip and sprinkler systems, and investing in tail water recovery and reuse systems.

To further maximize the efficiency of the water delivered to crops and to reduce the water necessary to meet crop needs, growers have implemented agronomic and water management practices. Examples of water management practices that are regularly implemented throughout the state include laser touch-up of fields, use of furrow checks, alternate row irrigation, contour farming, surge irrigation, use of temporary sprinklers, participation in both private and publicly sponsored water management services, soil moisture monitoring, and irrigation scheduling based on meteorological data. In addition, growers implement a series of agronomic management practices that help to conserve water. These practices include rotating crops, incorporating crop residue into the soil profile, soil and water quality testing, pre-irrigation surface conditioning, the use of transplants, mulching, shaping of furrows, and planting in the bottom of furrows.

Along with these on-farm conservation measures implemented by individual growers, agricultural water users, through membership in irrigation districts, have invested tens of millions of dollars in measures to efficiently distribute water through the larger irrigation distribution systems. One of the most significant, and most expensive, measures implemented by most irrigation districts to conserve water has been the lining of canals. To further conserve water, irrigation districts have invested in automated measuring and delivering systems and have implemented programs to maintain and improve the efficiency of water production wells. Several Arizona irrigation districts deliver water through underground pipelines. The Work Group estimates that hundreds of millions of dollars of such investments have been made in Arizona since the passage of Arizona's historic 1980 Water Code, however, precise data are not available.

Arizona Law establishes three agricultural water conservation programs, five active water management areas (AMA's), and three irrigation non-expansion areas (INA's). In the AMA's, growers must be regulated either under a base conservation program that uses fixed not-to-exceed quantity water allotments or may choose to be regulated under an Historic Cropping Program or an Agricultural Best Management Program, established by statute in 2003.

Ongoing private, State, and Federal programs stimulate, motivate, and provide incentives to both physical and management water conservation practices. The Environmental Quality Improvement Program (EQIP) of the Natural Resources Conservation Service (NRCS) is one example. As outlined on Table 6, EQIP has been very popular with Arizona growers. Between 1997 and 2002, more that 55,000 cropland acres statewide were under treatment, while total EQIP funds requested in Arizona were $90.8 million over that same period, but just $32.1 million in EQIP Program funding was allocated to the State. Informal conversation with several NRCS District Conservationists indicates that EQIP cost-shares many of the irrigated agriculture physical practices discussed above, including field leveling, ditch lining, efficient gates, turnouts, and ports, sprinkler systems, and culverts. The State of Arizona offers the Agricultural Water Conservation System Tax Credit. It offers incentive tax credits for investment in these same types of physical system improvements, including ditch lining, pipelines, field leveling, sprinkler and trickle systems, and tail water recovery systems. The USDA Risk Management Agency offers a Prevented Planting (drought) program as a part of its overall crop insurance programs (www.rma.usda.gov/news/2003/04/PreventedPlanting.pdf). Several

Table 6. Summary Information - Arizona EQIP Contracts

1999				
Land use	Number of Contracts	Amount ($1000)	% of Obligation	Acres Under Contract
Cropland	198	3146.8	61%	12329
Irrig. Pasture	23	221.2	4%	469
Rangeland	71	1822.5	35%	903451
Other	1	1.4	0%	4
Total	293	5191.9	100%	916253
2000				
Land use	Number of Contracts	Amount ($1000)	% of Obligation	Acres Under Contract
Cropland	126	2657.2	53%	8316
Irrig. Pasture	14	286.5	6%	2207
Rangeland	67	2038.8	41%	760746
Other				
Total	207	4982.5	100%	771269
2001				
Land use	Number of Contracts	Amount ($1000)	% of Obligation	Acres Under Contract
Cropland	135	3602.1	63%	12622
Irrig. Pasture	13	242.3	4%	602
Rangeland	60	1882.2	33%	532106
Other				
Total	208	5726.6	100%	545330
2002				
Land use	Number of Contracts	Amount ($1000)	% of Obligation	Acres Under Contract
Cropland	96	5743.8	56%	22249
Irrig. Pasture	32	830.7	8%	2113
Rangeland	64	3650.1	35%	991423
Other	2	58	1%	79
Total	194	10282.6	100%	1015864

Total funds requested since 1997 $ 90,800,155

Total funds allocated to Arizona since 1997 $ 32,137,550

Source: Data provided by Natural Resources Conservation Service district managers indicate that grower participation in this RMA Program was up sharply in 2003 and again in 2004.

An ongoing partnership between the Arizona Department of Water Resources, the Arizona Department of Agriculture, the NRCS, and the Bureau of Reclamation sponsors irrigation water management technical service providers who provide on-farm technical services. Their technical assistance is popular with growers, but limited by available staff time. They provide services including soil moisture monitoring, measurement of water applied, estimates of distribution and application efficiencies, estimates of run-off and deep percolation losses, cost analysis, conducting water management workshops, irrigation scheduling, testing pump efficiencies, and similar technical management services. Some irrigation districts sponsor the private sector provision of water management services. Private Certified Irrigation Specialists practice in Arizona's irrigated areas.

Survey Results – What Irrigation District Managers Say About the Potential of Conservation and Water Use Efficiency as Long-Term Drought Preparedness and Response Options

Our statewide survey of irrigation district managers listed thirteen water conservation drought preparedness and response items (see Survey Section Annex to Chapter IV). All twenty-two district managers responded to at least one of these thirteen items. The table below summarizes district manager responses in three categories: Physical conservation practices; management conservation practices; and other practices.

Conservation And Long-Term Drought Preparedness And Response

Conservation Practice	Already Available	No Help	Might Help	Potentially Important	Totals
Physical conservation practices *(five questions, 101 total responses)*	63	14	16	8	101
Management conservation practices *(four questions, 84 total responses)*	44	14	22	4	84
Other *(4 questions,82 total responses)*	19	20	29	14	82
- Greater water use efficiency *(n=22)*	7	4	4	7	22
- Use lower quality water *(n=20)*	2	8	8	2	20
- Study effect.–w.c. measures *(n=20)*	6	2	11	1	20
- Inc. acreage low water crops*(n=20)*	4	6	6	4	20

In this table, one response by one manager counts as one. For example, all 22 of the managers responded to the item, "Emphasize greater water use efficiency". Of the 22, seven said "Already available," four said "Would not help," four said "Might help some," and seven said "Potentially Very Important."

Physical Conservation Practices

The survey listed five physical conservation practices items:

- ✓ Use lasers for accurate land leveling
- ✓ Install return-flow systems

- ✓ Line canals or install piping to control seepage
- ✓ Use sprinkler and drip irrigation systems
- ✓ Install underground pipelines

The Work Group notes that these practices are generally included in the Arizona Best Management Practices – Agricultural Water Conservation Program categories of (1) Water Conveyance System Improvements, and (2) Farm Irrigation Systems. Altogether, 22 responding managers indicated 101 total responses to these 5 questions (because 110 or 5x22 total responses were possible, there were 9 non-responses).

Looking at the five physical practices, 77 of 101, or 76% of the total, said these were already available (63 responses) or would not help (14 responses). Only 24%, or 24 of 101, said these might help or were potentially very important. The responding districts can be sub-divided into those located within one of the State's five AMA's and those outside an AMA, as shown on the next chart.

Physical Conservation Practices and Location In or Not In an AMA

Location	Already Available, or No Help	Might Help, or Potentially Important
All locations *(five questions, 101 total responses)*	77 of *101*, or 76%	24 of *101*, or 24%
In an Active Management Area *(thirteen districts, 60 total responses)*	42 of *60*, or 70%	18 of *60*, or 30%
Not in an Active Management Area *(nine districts, 41 total responses)*	35 of *41*, or 85%	6 of *41*, or 15%

Thirteen responding districts were located in an AMA and nine were not (Table 7). The AMA districts were somewhat more likely to regard the five physical conservation practices as potentially helpful in drought preparedness, with about 30% positive responses from the AMA districts versus 15% positive from the non-AMA districts. Statewide, whether in or outside of an AMA, about 60% of the responses indicated that these measures were already available.

These results should be taken in the context of the introductory discussion, that enormous statewide investments have already been made by Arizona's irrigated agriculture in both district and on-farm water conservation, and that incentive programs have been in place over many years in most of Arizona's irrigation districts. For those districts and growers who have yet to adopt these types of physical practices, a continuing attention to them may still hold some potential.

Management Conservation Practices

The survey listed four management conservation practices items:

- ✓ Schedule irrigation by crop water demand
- ✓ Schedule irrigation by soil moisture monitoring
- ✓ Improve tillage practices
- ✓ Use evaporation suppressants

The Work Group notes that these practices are generally included in Arizona's Best Management Practices – Agricultural Water Conservation Program categories (3) Irrigation Water Management, and (4) Agronomic Management. Altogether, the 22 managers indicated 84 responses to these four items (because 22x4 = 88 total responses were possible, there were 4 non-responses).

Looking at the four management practices, 58 of 84, or 69% of the total, said these were already available (44 responses) or would not help (14 responses). Only 26 of 84 (31%) said these might help or were potentially very important. The districts can again be sub-divided into those located within one or outside an AMA:

Management Conservation Practices and Location In or Not In an AMA

Location	Already Available, or No Help	Might Help, or Potentially Important
All locations *(four questions, 84 total responses)*	58 of *84*, or 69%	26 of *84*, or 31%
In an Active Management Area *(thirteen districts, 49 total responses)*	32 of *49*, or 65%	17 of *49*, or 35%
Not in an Active Management Area *(nine districts, 35 total responses)*	26 of *35*, or 74%	9 of *35*, or 26%

The AMA districts were again slightly more likely to regard the four management conservation practices as potentially helpful in drought preparedness, with about 35% positive responses from the AMA districts versus 26% positive from the non-AMA districts. Overall, whether in or outside of an AMA, a majority of all responses indicated that these measures were already available.

This breakdown is similar to the response to the physical practices items. A majority of district managers may see limited conservation potential in management-type approaches, perhaps reflecting a view that the performance of most growers is already high in this area. Again, for the districts and growers who have yet to adopt these types of management practices, a continuing attention to them may still hold some potential.

Other Conservation Items
The survey listed four other conservation practices items:
- ✓ Emphasize greater water use efficiency
- ✓ Use lower quality water
- ✓ Study effectiveness of water conservation measures
- ✓ Increase acreage of low water using or drought-tolerant crops

Altogether, the 22 managers indicated 82 responses to these four items (because 88 total responses were possible, there were 6 non-responses).

Looking at the four practices, 39 of 82, or 48% of the total, said these were already available (19 responses) or would not help (20 responses), while 43 of 82, or 52% said these might help or were potentially very important. This breakdown is somewhat different than the 76-24 split evidenced in the physical and the 69-31 split in the management items. District managers may feel that there is somewhat more conservation potential in these ideas: The exact 50-50 split in response to "Emphasize greater water use efficiency" is illustrative.

Discussion: The Potential of Conservation and Water Use Efficiency as Long-Term Drought Preparedness and Response Options

Great progress has already been made in irrigation district and on-farm agricultural water conservation in Arizona. Again quoting one of the responding district managers:

> "As far as adaptation, the majority of farmers do everything economically possible to reduce water use, as it is their largest expense." (See Annex to Chapter IV)

Nonetheless, voluntary incentive programs focused on cost-shares, low-interest loans, and tax credits for physical conservation items undoubtedly do hold promise for some growers.

Voluntary water management-oriented programs such as irrigation mobile laboratories, Technical Service Providers (both private and public), and USDA/RMA Crop Insurance appear to have been effective and popular with growers and may also hold promise as longer-term drought preparedness options.

The approximate 50-50 split in views about the usefulness of 'other' conservation items is noteworthy. It may suggest other long-term preparedness possibilities for the State. Exactly half of the responding managers felt that emphasizing greater water use efficiency might help or was potentially important.

Discussion: Shorter-Term vs. Longer-Term Preparedness and Response

Consider a shorter time period of, say, 6-18 months vs. a longer time period of, say, two years or more. Effective or feasible preparedness and response measures over the shorter time frame may be much less feasible over the longer, and vice-versa. For example, a review of agricultural sector drought response measures **from other states** suggests possible adaptations such as the following:

- ✓ switch to lower water use crops
- ✓ reduce irrigated acreage
- ✓ switch to more drought tolerant crops
- ✓ lower target yields
- ✓ apply less water to the same area
- ✓ reduce water allotments/allocations
- ✓ grow crops with shorter maturity periods
- ✓ reduce acreage cropped in the summer and increase in the winter

The Irrigated Agriculture Work Group views these types of potential drought responses as short-term in nature. Essentially, they are forced responses to short-term emergencies.

Some of this behavior did occur in some especially vulnerable Arizona irrigation districts in 2003, and is likely to occur again in 2004. Over a longer-term, these types of forced responses will not sustain the long-term economic viability of Arizona's irrigated agriculture. A quote from one of the responding managers is illustrative:

> "The statement on using drought tolerant crops has two major problems to overcome. There must be a demand for such crops and second financing becomes a big issue, as most growers use ginning co-ops for their current financial institution." (See Chapter IV Annex).

Economics – costs and returns – drive crop choice and acres planted. Water demand derives from those economic choices, which are also heavily influenced by Federal commodity programs and Arizona tax law. In Arizona, a forced short-term emergency approach to drought is likely to result not only in severe negative economic consequences on affected croplands, but also to engender severe negative secondary impacts on ginners, elevators, input dealers, and main street business whose economic well being is tied to a healthy, economically strong primary production sector. Preparedness for long-term drought might more productively focus on the vulnerabilities to drought analyzed in Chapter II, and on the preparedness items that a majority of the responding district managers ranked as "might help," and "potentially very important" items.

Conclusions: The Potential of Increased Water Conservation As A Long-Term Drought Response In Arizona

Most promising conservation approaches:

- ✓ Expand physical and structural incentive programs such as EQIP, targeting the most vulnerable areas of the State and growers who may still benefit from voluntary participation in these programs.
- ✓ Broaden the reach of agronomic and irrigation water management and education programs, along the lines of ongoing private sector and ADA/ADWR/NRCS irrigation mobile lab and TSP programs and the Agricultural Water Conservation – Best Management Practices Program. Again, target the most vulnerable areas of the State and growers who may still benefit from voluntary participation.
- ✓ With a focus on preparedness, investigate the potential of tax credits, low-interest loans, drought insurance, and other incentives to conservation, along the lines of the existing Arizona Agricultural Water Conservation System Tax Credit program and the USDA/FSA Prevented Planting Crop Insurance Program.
- ✓ Support broader policy initiatives that show promise for Arizona: Maintain and modernize existing water facilities, support initiatives that allow existing water supplies to be used more effectively, use collaborative and voluntary market-based approaches, and lower institutional barriers to more effective water use.

Voluntary, Market-Driven Water Transfers And Drought Preparedness And Response

The statewide survey of irrigation district managers asked whether increasing the ease or ability for short-term, voluntary, market driven water transfers was already available, would not help, might help some, or was potentially very important. Responses are shown on the following table:

Item	Already Available	No Help	Might Help	Potentially Important	Totals
Market-driven water transfers *(one question, 19 total responses)*	0	4	6	9	19

Looking at the table, four managers (21%) said this would not help, while fifteen (79%) said this either might help some or was potentially very important. A majority of the responding managers see voluntary transfers as a potentially useful tool in drought preparedness and response.

In fact, there have already been a number of voluntary water transfers in Arizona. Water transfers can be structured to benefit both those releasing and those receiving water. Looking at several of the chief vulnerability characteristics from Chapter II (Table 3), voluntary transfers offer one means to reduce reliance on single supplies, to abate severe shortages, or to lessen the impact of sudden supply changes, for example. Under carefully controlled conditions, water transfers can provide economic benefits that can help to sustain both water lessees and lessors. But, the opposite has also occurred in the West.

Water transfers are a charged subject in Arizona and generally in the arid southwest. Any program to facilitate willing, voluntary, market-driven transfers would require careful consideration and design. Several illustrative comments on transfers were received from the survey respondents:

> "As senior entitlement holders on the Colorado River, we are last to be affected, but a source and target for more junior water rights holders."

> "(I) fear that proposing to…..increase the ease/ability for short-term market driven water transfers might backfire."

Voluntary, willing, term-limited, and market-driven water transfers may offer promise as one avenue towards both short-term response and long-term drought preparedness in Arizona, but great care will be required as this avenue is explored.

Planning, Research, And Drought Preparedness And Response

Our statewide survey of irrigation district managers listed four planning and research drought preparedness and response items (see Chapter Annex – Survey Section IV):

- ✓ Develop a state water plan
- ✓ Research drought impact on various groups
- ✓ Investigate farm diversification strategies

✓ Evaluate water quality and quantity from new sources

Either eighteen or twenty district managers responded to each item. The table below summarizes their responses.

Planning And Research And Long-Term Drought Preparedness And Response

Planning or Research Item	A . A.	No Help	Might Help	P. I.	Totals
(4 questions, 78 total responses)	6	27	28	17	78
- State water plan *(n=20)*	1	4	10	5	20
- Research impact on groups *(n=20)*	1	10	6	3	20
- Farm diversification strategies *(n=20)*	2	7	7	4	20
- Evaluate Q&Q-new sources *(n=18)*	2	6	5	5	18

In this table, one response by one manager counts as one. For example, all 20 of the managers responded to the item, "Develop a state water plan". Of the 20, one said "Already available," four said "Would not help," ten said "Might help some," and five said "Potentially very important."

Looking at the four research and planning items together, 33 of 78, or 42%, said these were already available (6 responses) or would not help (27 responses), while 58%, or 45 of 78, said these might help or were potentially very important.

Among the individual items, the idea of developing a state water plan received the most positive responses, 15 of 20, or 75%. Only the idea of researching impact on various groups received an overall negative response, with eleven of twenty managers responding either "Already available," or "Would not help."

Overall, the district manager response to these planning and research items was slightly positive, perhaps because these items do not appear to address the higher-ranking vulnerability circumstances from Chapter II.

Eastern and South Eastern Arizona

GVID informants indicated that all 27 drought preparedness and response items either might help some or were potentially very important. The GVID district manager indicated that the more important items included developing drought triggers, early warning systems, and a statewide water plan. Drought property tax credits and guaranteed low-interest loans for drought-stricken farmers were also potentially very important. Promising conservation measures included canal lining, underground pipelines, and irrigation scheduling by crop water demand.

In the Upper Gila Valley – Safford area, informants suggested that, because of the institutional organization of water rights, farmers have little incentive to conserve water, in that any water saved by one simply becomes available for use by another, without compensation. Also, there was a need to reconcile agricultural with environmental issues: Measures such as canal lining might conflict with environmental rules and regulations.

As an agricultural region dependant on groundwater for irrigation, the SSV provides insights into both the vulnerability of Arizona's irrigated agriculture and the adaptation strategies that may contribute to the long-term economic viability of irrigated agriculture in a semiarid environment where access to water is an increasingly limiting factor.

Large-scale commercial agriculture became possible in the Sulphur Spring Valley with the establishment of the Sulphur Springs Valley Electrical Cooperative in the 1940s. Inexpensive energy to power electric pumps for irrigation, plus increased demand for cotton during World War II, led to a farming boom, inducing farmers from less productive regions to relocate in the SSV. By 1955, the SSV had 299 commercial farmers producing mainly cotton and corn. Agricultural acreage expanded rapidly until 1976 when irrigated acreage reached a peak of 160,000 acres. Then, a combination of crises struck the region and agriculture decline precipitously. The first crisis involved the local aquifers. Annual water withdrawal began to exceed recharge in the late 1960s and static water depths began to drop. Droughts between 1973 and 1980 exacerbated the problem to the point that, in 1980, part of the region was declared as an Irrigation Non-Expansion Area and no new Irrigation Acres were allowed. At the same time, the energy crisis of 1976 led to an exorbitant increase in the price of natural gas. In combination, these climatic and economic events drove a large number of farming families out of the region and, in the course of a few years, irrigated acreage declined by more than 66 percent, the largest decline of any agricultural region in Arizona.

Adaptation in the Sulpher Springs Valley

In the Sulphur Springs Valley, farmers expect and have adapted to a great deal of climatic variability from one year or season to the next and are interested climate variation that would affect the water table. Because farmers perceive that winter precipitation is the main source of aquifer recharge, they want **winter precipitation forecasts that extend two to five years into the future**. This knowledge would have direct relevance on decisions to deepen wells, to continue improving the efficiency of irrigation technology, to change cropping strategies, or perhaps to leave farming.

The repeated water supply crises in the SSV have prompted adaptations that include **changes in irrigation technology** and **crop diversification** in response to market signals. An important adaptation to low and erratic precipitation has been the adoption of more **water efficient irrigation technologies**. By the beginning of the 1990s, most larger farmers had replaced older flood furrow irrigation systems with newer center pivots, sprinklers, and drip irrigation. The newer technologies use less water per hectare, decrease evaporation rates and variable water costs, and increase field irrigation efficiency.

Crop diversification has also been an important adaptation. Some abandoned fields were changed to fruit, pecan, and pistachio orchards. Other parcels were converted to foodgrade corn, chile, lettuce, and a wide variety of other vegetables. Those who continue to grow traditional row crops such as corn, sorghum, cotton, and alfalfa generally do it in combination with other crops. Also, because of high water costs, farmers are increasingly targeting niche markets such as those for organic fruits and vegetables and U-pick farms. Since the early 1990s, one cucumber and two tomato greenhouses have been constructed in the area. These raise crops in a controlled environment where temperature and humidity are constantly adjusted to meet plant requirements and production is intensive year-round.

Public policy has played an important role in facilitating these changes. Since the 1940s, farmers have benefited substantially from a variety of federal commodity programs. More recently, the Environmental Quality Improvement Program – **EQIP** – and other Federal and State programs have provided farmer incentives to adopt of water efficient irrigation technologies. **Crop insurance**, including prevented planting insurance, is becoming increasingly important in allowing farmers to recuperate from extreme events.

All of these adaptation strategies have allowed SSV growers to become better prepared to deal with future extreme climatic and economic conditions, but their adoption has not been uniform. **Smaller farmers** – those cultivating smaller plots of land – have been less capable of adopting new technologies or diversifying crop production and are more vulnerable to climatic extremes. For such farmers, any crop loss represents a larger portion of overall profits. Also, given the localized nature of rainfall in the valley, cultivating larger amounts of land reduces the overall risk of climate-related damage. Smaller farmers also have less access to financial capital, which limits possibilities for adopting more expensive new technologies, so most of these growers continue to use more costly flood irrigation techniques.

TABLE 7. Response, Mitigation, and Adaptation Options: District Manager Views

			PROGRAMS																FORECASTING AND EARLY WARNING																			
IRRIGATION DIST	COU	AF	Propety tax credit				Low interest loans				Invest-w.s. sources				Permit-w.s. sources				Drought triggers				Early warning				New data collection				Monitor supplies				nnoff & supply foreca			
		(00+01)/2	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI
Central Arizona I	Pina	227214			1					1			1				1				1				1			1					1				1	
Cortaro-Marana I	Pima	33500																															1					
Harquahala Valle	Mari	97182			1				1				1				1				1				1				1				1				1	
Hilander "C" Irrig	Yum	0		1				1					1			1				1				1					1			1				1		
Hohokam Irrigati	Pina	74525			1				1				1				1					1			1		1						1		1			
Hyder Valley Irri	Mari	4				1																																
Maricopa-Stanfie	Pina	236350			1				1				1			1			1						1			1					1				1	
Maricopa Water I	Mari	57700				1				1			1					1			1				1			1					1					1
McMullen Valley I	LaPa	0		1						1		1				1			1					1				1				1				1		
New Magma Irrig	M-P	91799			1					1			1				1					1				1				1	1							1
New State Irrigat	Mari	717			1				1			1					1		1						1		1					1			1			
Roosevelt Water	Mari	98440			1					1			1				1				1					1			1					1				1
Roosevelt Irrigat	Mari	167898								1											1					1			1				1					1
Salt River Projec	Mari	149597			1				1				1			1			1				1				1				1						1	
San Carlos Irriga	Pina	56343				1			1				1				1				1				1			1			1						1	
San Tan Irrigatio	Mari	3222			1					1				1				1				1				1				1				1				1
Tonopah Irrigatio	Mari	14785															1		1				1					1			1					1		
Unit "B" Irrigatio	Yum	27612				1				1			1				1					1			1				1					1				1
Wellton-Mohawk	Yum	400000			1			1				1				1			1				1				1					1						1
Yuma Irrigation I	Yum	61069												1								1	1					1			1				1			
Yuma County Wa	Yum	244108		1				1				1				1					1		1				1				1				1			
Paloma Irrigation	Mari	137545				1				1				1				1			1		1				1				1						1	
Column totals		2179610	0	3	10	5	0	3	6	9	0	4	11	3	0	6	9	3	6	1	8	5	6	2	8	4	6	7	5	2	7	4	7	3	4	3	6	7
Total manager responses			18				18				18				18				20				20				20				21				20			

'Normal' Acre Feet delivered, from Table 2 *(1,000's)*

A = Already available.

NH = Would not help.

MH = Might help some.

PI = Potentially very important.

TABLE 7. Response, Mitigation, and Adaptation Options: District Manager Views

CONSERVATION

IRRIGATION DIST	COU	AF (00+01)/2	Emphasize efficiency				Lasers for leveling				Return flow systems				Lining/piping				Sprinklers/drip				Schedule by crop				Schedule by soil			
			A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI
Central Arizona I	Pina	227214			1			1				1				1				1				1					1	
Cortaro-Marana I	Pima	33500			1																				1				1	
Harquahala Valle	Mari	97182				1	1				1				1				1						1				1	
Hilander "C" Irric	Yum	0		1				1				1				1			1				1				1			
Hohokam Irrigati	Pina	74525	1				1				1				1				1				1				1			
Hyder Valley Irri	Mari	4				1													1				1				1			
Maricopa-Stanfie	Pina	236350	1				1				1				1				1				1				1			
Maricopa Water I	Mari	57700				1			1				1				1				1				1				1	
McMullen Valley	LaPa	0	1				1				1				1				1				1				1			
New Magma Irric	M-P	91799		1			1						1		1				1				1				1			
New State Irrigat	Mari	717				1		1					1		1				1				1				1			
Roosevelt Water	Mari	98440		1			1				1				1				1				1				1			
Roosevelt Irrigat	Mari	167898				1	1				1				1				1				1				1			
Salt River Projec	Mari	149597			1		1				1				1				1				1				1			
San Carlos Irriga	Pina	56343			1		1						1					1			1		1				1			
San Tan Irrigatio	Mari	3222				1				1				1				1				1				1			1	
Tonopah Irrigatic	Mari	14785	1				1				1				1				1				1				1			
Unit "B" Irrigatio	Yum	27612				1	1				1					1						1			1				1	
Wellton-Mohawk	Yum	400000	1				1				1				1				1					1				1		
Yuma Irrigation I	Yum	61069	1				1								1				1				1				1			
Yuma County Wa	Yum	244108		1			1				1						1		1				1					1		
Paloma Irrigation	Mari	137545	1				1				1				1						1		1				1			
Column totals		2179610	7	4	4	7	15	3	1	1	12	2	4	1	13	3	2	2	15	1	3	2	15	2	4	1	14	2	6	0
Total manager responses			22				20				19				20				21				22				22			

'Normal' Acre Feet delivered, from Table 2 *(1,000's)*
A = Already available.
NH = Would not help.
MH = Might help some.
PI = Potentially very important.

IRRIGATION DIST	COU	AF (00+01)/2	Tillage practices				Evaporation suppress				Lower-quality water				Under. pipelines				Study measures				Low water crops			
			A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI
Central Arizona I	Pina	227214		1					1				1			1					1				1	
Cortaro-Marana I	Pima	33500															1									
Harquahala Valle	Mari	97182			1					1		1					1				1				1	
Hilander "C" Irrig	Yum	0		1				1				1				1				1				1		
Hohokam Irrigati	Pina	74525	1						1			1					1		1						1	
Hyder Valley Irri	Mari	4					1						1		1											
Maricopa-Stanfie	Pina	236350	1				1						1		1				1				1			
Maricopa Water I	Mari	57700			1				1				1				1				1			1		
McMullen Valley I	LaPa	0	1					1				1			1				1					1		
New Magma Irrig	M-P	91799	1					1						1		1			1					1		
New State Irrigat	Mari	717			1				1				1			1					1					1
Roosevelt Water	Mari	98440	1				1					1			1						1		1			
Roosevelt Irrigat	Mari	167898								1				1	1						1				1	
Salt River Projec	Mari	149597	1					1					1		1				1				1			
San Carlos Irriga	Pina	56343	1						1		1							1			1					1
San Tan Irrigatio	Mari	3222				1			1				1					1				1				1
Tonopah Irrigatio	Mari	14785	1				1														1					1
Unit "B" Irrigatio	Yum	27612			1				1				1				1				1				1	
Wellton-Mohawk	Yum	400000		1					1			1				1				1					1	
Yuma Irrigation I	Yum	61069	1					1				1			1						1			1		
Yuma County Wa	Yum	244108		1				1				1					1				1			1		
Paloma Irrigation	Mari	137545	1				1				1				1				1				1			
Column totals		2179610	10	4	4	1	5	6	8	2	2	8	8	2	8	5	6	2	6	2	11	1	4	6	6	4
Total manager responses			19				21				20				21				20				20			

Table title: TABLE 7. Response, Mitigation, and Adaptation Options: District Manager Views *(cont.)* — CONSERVATION

'Normal' Acre Feet delivered, from Table 2 *(1,000's)*

A = Already available.

NH = Would not help.

MH = Might help some.

PI = Potentially very important.

			TABLE 7. Response, Mitigation, and Adaptation Options: District Manager Views																			
			WATER MARKETS				*PLANNING AND RESEARCH*															
IRRIGATION DIST	COU	AF	Transfers				State water plan				Research impacts				Farm diversification				New sources			
		(00+01)/2	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI	A	NH	MH	PI
Central Arizona I	Pina	227214				1				1			1				1				1	
Cortaro-Marana I	Pima	33500																				
Harquahala Valle	Mari	97182			1				1				1					1				1
Hilander "C" Irrig	Yum	0				1		1				1				1					1	
Hohokam Irrigati	Pina	74525				1				1			1				1				1	
Hyder Valley Irri	Mari	4																				1
Maricopa-Stanfie	Pina	236350			1		1					1			1							
Maricopa Water I	Mari	57700				1			1				1					1		1		
McMullen Valley I	LaPa	0		1				1				1				1				1		
New Magma Irrig	M-P	91799				1				1				1			1					1
New State Irrigat	Mari	717			1				1				1				1		1			
Roosevelt Water	Mari	98440			1					1			1			1					1	
Roosevelt Irrigat	Mari	167898			1				1					1				1				
Salt River Projec	Mari	149597		1					1			1				1			1			
San Carlos Irriga	Pina	56343		1				1				1					1			1		
San Tan Irrigatio	Mari	3222				1				1				1			1					1
Tonopah Irrigatio	Mari	14785							1			1					1					
Unit "B" Irrigatio	Yum	27612				1			1		1					1						1
Wellton-Mohawk	Yum	400000		1				1				1						1		1		
Yuma Irrigation I	Yum	61069				1			1			1				1				1		
Yuma County Wa	Yum	244108			1				1			1				1				1		
Paloma Irrigation	Mari	137545				1			1			1			1						1	
Column totals		2179610	0	4	6	9	1	4	10	5	1	10	6	3	2	7	7	4	2	6	5	5
Total manager responses			19				20				20				20				18			

'Normal' Acre Feet delivered, from Table 2 *(1,000's)*

A = Already available.

NH = Would not help.

MH = Might help some.

PI = Potentially very important.

Chapter V Annex

*Irrigated Agriculture Survey Section IV:
Response, Mitigation, and Adaptation*

IV. RESPONSE, MITIGATION, AND ADAPTATION

The following is a list of items that might help the DISTRICT and its growers avoid or mitigate long-term drought, or respond and adapt to it.

Please tell us whether, in your opinion, these items are already available to the DISTRICT or to its farmers. If the items are not already available, in your opinion, would they be of no help, might they help some, or might they be potentially very important in responding, mitigating, and adapting to long-term drought?

Already Available	Would Not Help	Might Help Some	Potentially Very Important	Response Item
☐	☐	☐	☐	Develop criteria to trigger drought-related actions
☐	☐	☐	☐	Develop an early warning system
☐	☐	☐	☐	Develop a state water plan
☐	☐	☐	☐	Establish new data collection networks
☐	☐	☐	☐	Monitor vulnerable water supplies
☐	☐	☐	☐	Improve accuracy of seasonal runoff and water supply forecasts
☐	☐	☐	☐	Research drought impact on various groups
☐	☐	☐	☐	Investigate farm diversification strategies
☐	☐	☐	☐	Create drought property tax credit program for farmers
☐	☐	☐	☐	Program providing guaranteed low-interest loans to drought-stricken farmers
☐	☐	☐	☐	Increase the ease/ability for short-term, voluntary, market driven water transfers
☐	☐	☐	☐	Emphasize greater water use efficiency
☐	☐	☐	☐	Investment program to increase flexibility of water supply sources
☐	☐	☐	☐	Emergency permit program to increase flexibility of water supply sources
☐	☐	☐	☐	Use lasers for accurate land leveling
☐	☐	☐	☐	Install return-flow systems
☐	☐	☐	☐	Line canals or install piping to control seepage
☐	☐	☐	☐	Use sprinkler and drip irrigation systems
☐	☐	☐	☐	Schedule irrigation by crop water demand
☐	☐	☐	☐	Schedule irrigation by soil moisture monitoring
☐	☐	☐	☐	Improve tillage practices

Already Available	Would Not Help	Might Help Some	Potentially Very Important	Response Item
☐	☐	☐	☐	Use evaporation suppressants
☐	☐	☐	☐	Use lower-quality water
☐	☐	☐	☐	Install underground pipelines
☐	☐	☐	☐	Study effectiveness of water conservation measures
☐	☐	☐	☐	Increase acreage of low water using or drought-tolerant crops
☐	☐	☐	☐	Evaluate water quality & quantity from new sources

In your opinion, are there any other drought response and mitigation measures that might help the District and its growers avoid or mitigate long-term drought, or respond and adapt to it?

Please list any other comments, ideas, or questions you might have concerning the current drought and the Governor's Drought Task Force – Irrigated Agriculture Work Group?

Chapter V Annex

All Comments Made By Survey Respondents
(Organized by Survey Section)

Comments from Survey Section IV: Response, Mitigation, and Adaptation

From SRP:
Enforce the surface water code

From Highlander 'C':
We would like a source of inexpensive power for our wells, but this is not related to the drought (unless the drought causes power prices to rise).

From YCWUA :
Have reclamation run the Yuma desalter. If not, shut down entirely, as it is too costly to maintain if it is never to be used. Running it saves about 100,000 af/yr.

From Paloma IDD:
Continue to laser level; Continue to grow crops with shorter maturity date; Continue to summer fallow ground that may use more water

From Hohokam IDD:
Storage is a big issue.

From New Magma IDD :
In my opinion, nothing can take the place of research and planning to develop an early warning system. Such a system would benefit all the water using community. As far as adaptation, the majority of farmers do everything economically possible to reduce water use, as it is their largest expense. The statement on using drought tolerant crops has two major problems to overcome. There must be a demand for such crops and second financing becomes a big issue, as most grower's use ginning coops for their current financial institution

From Tonopah ID:
Fears that proposing to create drought property tax credit program, program providing guaranteed low-interest loans, or an increase in ease/ability for short-term market driven water transfers might backfire.